Longline Fishing For Deep-Swimming Tunas In The Central Pacific, 1953

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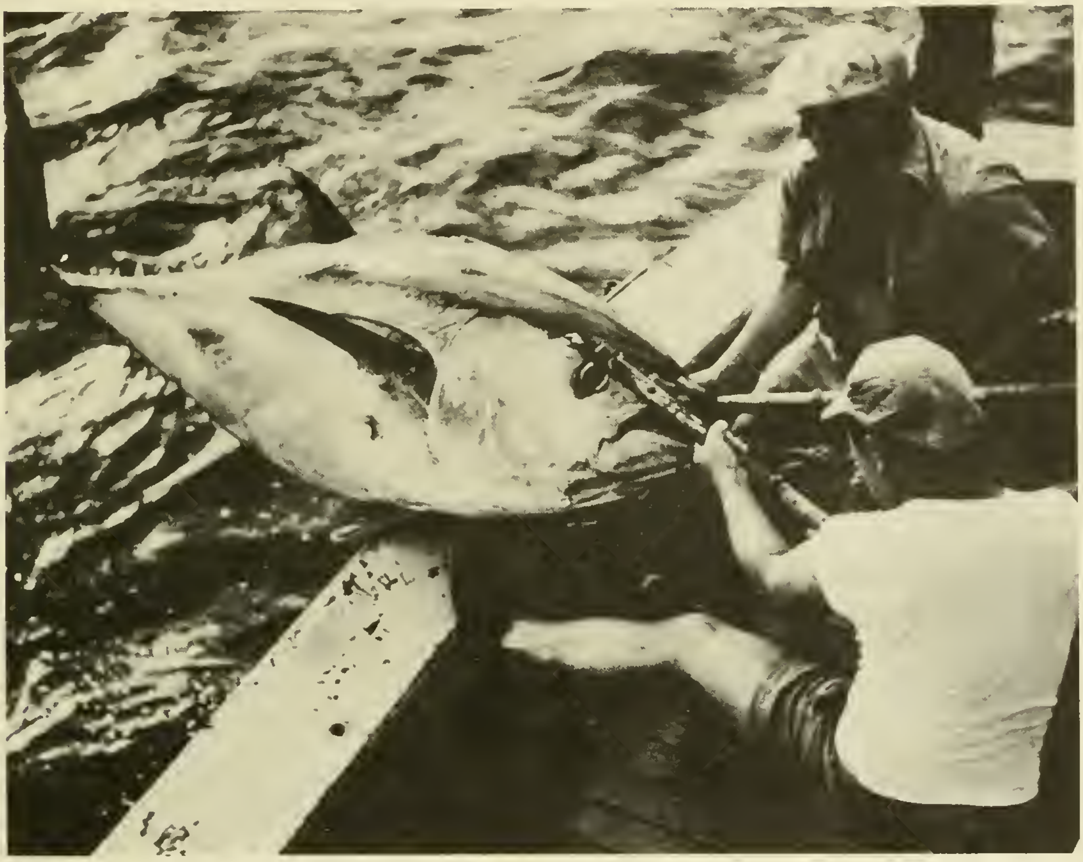

LONGLINE FISHING FOR DEEP-SWIMMING TUNAS IN THE CENTRAL PACIFIC, 1953

By

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This is the fourth[1/] in a series of reports on a survey of the deep-swimming tunas of the central equatorial Pacific. This survey has been conducted by the Pacific Oceanic Fishery Investigations (POFI) as a portion of a larger investigation embracing the hydrography and productivity of the central Pacific as well as the fishery resources (Sette MS).

Herein we summarize the salient features of six equatorial fishing cruises made between 140° W. and 170° W. longitude in 1953 (table 1, fig. 1). In addition, the results of a considerable amount of Japanese fishing in 1953 between 160° W. longitude and 180° are discussed. Complete summaries of the POFI cruises and of the catch data from the Japanese fishing are given in the appendix.

We use the vernacular names of the fishes throughout this report. These, with their commonly accepted scientific names, are listed below:

White-tipped shark, *Carcharinus longimanus* (Poey)
Silky shark, *Carcharinus* sp.[2/]
Great blue shark, *Prionace glauca* (Linnaeus)
Bonito shark, *Isurus glaucus* (Müller and Henle)
Marlin, *Makaira* sp.
Sailfish, *Istiophorus orientalis* (Schlegel)
Wahoo, *Acanthocybium solandri* (Cuvier and Valenciennes)
Dolphin, *Coryphaena hippurus* (Linnaeus)
Yellowfin tuna, *Neothunnus macropterus* (Temminck and Schlegel)

[1/] Fishing from July 1950 to December 1952 is summarized in Murphy and Shomura 1953a, b, and 1955.

[2/] A species closely resembling *C. floridanus* Bigelow, Schroeder, and Springer, and *C. ahenea* (Stead).

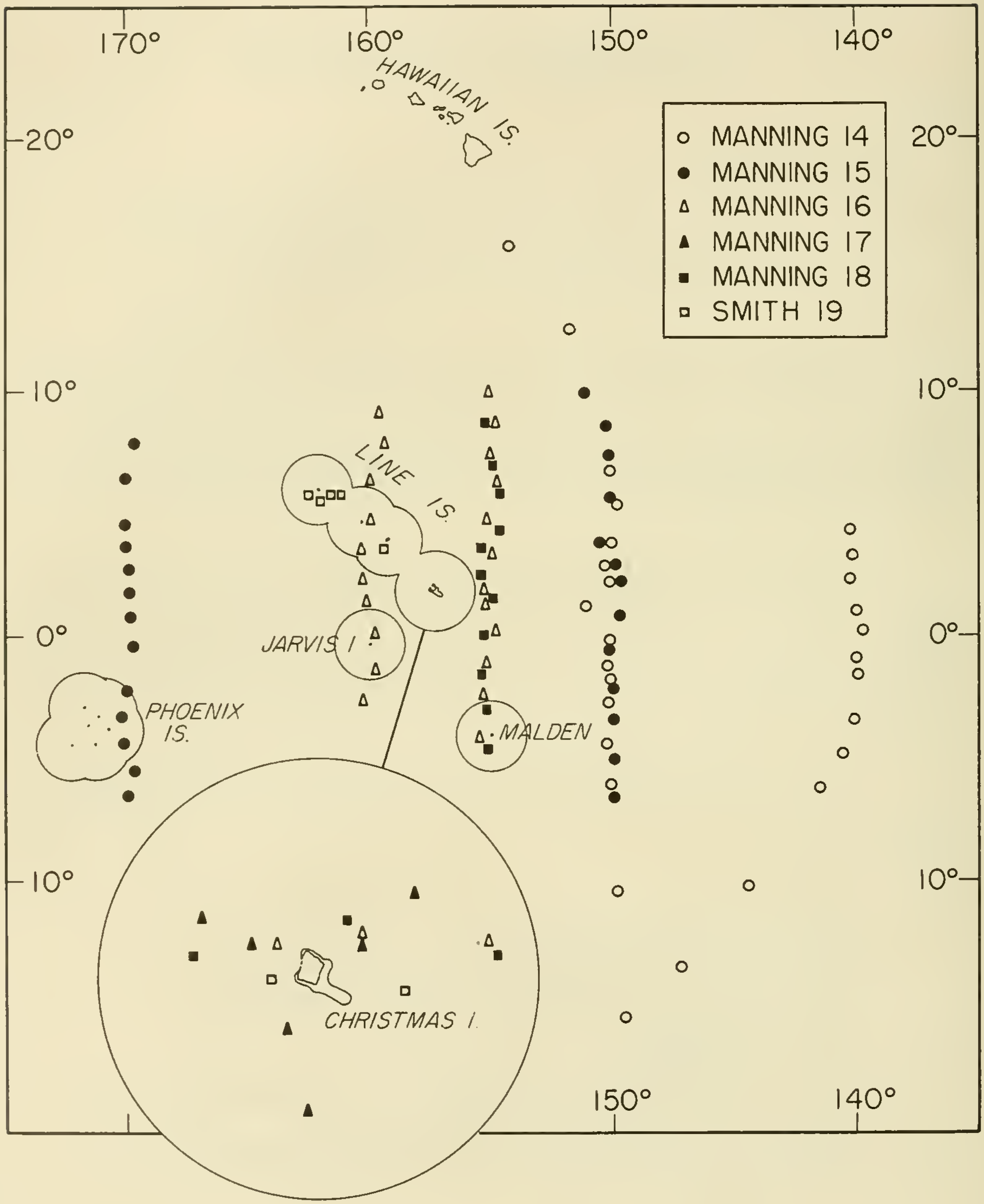

Figure 1.--Location of fishing stations during 1953, John R. Manning cruises 14 through 18, Hugh M. Smith cruise 19. The stations within 80 miles of land are enclosed in circles. Stations fished near Christmas Island appear in the insert.

Bigeye tuna, *Parathunnus sibi* (Temminck and Schlegel)
Skipjack, *Katsuwonus pelamis* (Linnaeus)
Albacore, *Germo alalunga* (Bonnaterre)
Lancet fish, *Alepisaurus* sp.
Barracuda, *Sphyraena barracuda* (Walbaum)

Table 1.--Period and general area of POFI longline fishing in the equatorial Pacific, 1953

Vessel and cruise	Period of operation	General fishing area
J. R. Manning, cruise 14	January-March	140°W., 150°W.
H. M. Smith, cruise 19	January-February	Line Islands
J. R. Manning, cruise 15	April-June	150°W., 170°W.
J. R. Manning, cruise 16	July-August	155°W., 160°W., and 155°W. to Christmas Island
J. R. Manning, cruise 17	October-November	Christmas Island
J. R. Manning, cruise 18	December	155°W., 155°W. to Christmas Island

ACKNOWLEDGEMENTS

So large a venture could hardly have been accomplished without the cooperation of most of the staff of POFI including the officers and crews of our research vessels. Miss Jean S. Halling assisted in processing the catch records. The temperature sections were prepared by T. S. Austin and the writers.

DESCRIPTION OF GEAR AND OPERATIONAL METHODS

Descriptions of the longline gear used by POFI have appeared in previous reports (Murphy and Shomura 1953a, b, Niska, 1953) and may be summarized as follows. One unit of gear, called a basket, has 1,260 feet of mainline and six 88-foot branch lines (droppers) attached to the mainline at 30-fathom intervals. Several baskets are joined to make up a set, the entire set being buoyed with floats at basket junctures and at the ends. Fishing at subsurface levels is accomplished by using 10-fathom lines between mainlines and floats and by setting the mainline slack so that it will sag in the water. To this end, the 1,260 feet of mainline is set in about 900 linear feet.

Some experimental gear was fished on each of the six cruises in 1953 in order to determine whether modifications of the standard gear would decrease the labor of handling the gear or increase the catch per unit of gear. The details of each type of special gear and the results from its use will be discussed in a separate section; the discussions of distribution and abundance are based on the standard gear described above.

The daily operations during the 1953 cruises were similar to those of earlier cruises. Setting started at dawn and took a little over an hour. Either fresh frozen sardines or herring were used as bait. Hauling commenced around noon, and the last basket set was the first to be hauled. Although the total time taken for hauling differed somewhat from station to station, the line was usually all on board at about 4:30 p.m. Further details of the work schedule for each station of the several cruises are given in appendix tables 22 through 27.

DISTRIBUTION AND ABUNDANCE OF TUNAS

The fishing cruises prior to 1953 were designed to cover a wide expanse of the equatorial Pacific (180°-120°W. longitude) in order to delimit the general area in which yellowfin were most abundant.

These surveys revealed a zone of high abundance between 140°W. and 160°W. longitude (Murphy and Shomura 1953a, b, 1955). Within these longitudes yellowfin were most abundant in the latitudinal belt enriched by the equatorial upwelling described by Cromwell (1953), the best catches usually being made between 1°N. and 6°N. latitude.

During 1953 attention was focused on a narrower range of longitudes (140°W. to 170°W.) in order to study more effectively latitudinal and seasonal variations in yellowfin abundance in the most promising area. In addition, special studies were made of the tuna populations in the vicinity of the Line Islands (fig. 1).

In our discussion, the longline stations for 1953 are separated into two categories, oceanic and insular, the latter being those located within 80 miles of land. This separation, in part arbitrary, was made in order to determine whether the abundance and the size of longline tuna are related to the nearness of land. The line of demarcation chosen probably eliminates the influence of the islands from the oceanic stations, as it seems unlikely that the presence of the small Line Islands significantly alters the environment for tuna as far as 80 miles

offshore, but, on the other hand, the stations classed as insular may in some instances be outside of any influence of the islands.

Yellowfin Tuna

In this section we shall consider variations in the location of the center of abundance of oceanic yellowfin tuna in the central equatorial Pacific during 1953. We are somewhat handicapped because sampling was not adequate over the entire area during most seasons. There are, however, clear indications that the population is not static in space, and there is on hand for 1953 enough information to develop a preliminary hypothesis.

The catch results presented graphically in figures 2 and 3 can best be studied by considering the temporal changes in yellowfin abundance first by longitude, then by latitude, and finally as an integrated whole.

In terms of longitude, during February and March yellowfin were more abundant (about 10 per hundred hooks) to the east (140°W.) than they were farther west (150°W.) (fig. 2), where about 3 were taken per hundred hooks fished. Unfortunately, there is no information from west of 150°W. for this period, so there is no way of knowing whether the trend continued in that direction unless the poor catches in April near 180° are regarded as evidence that the trend did continue west (fig. 3). Later in the year, during May and June, catches of 9 yellowfin per hundred hooks were made along 150°W., but the north-south extent of the area of high catches was limited (only two stations), while on 170°W. a much wider band of good fishing (around 7 per hundred hooks) was found, suggesting that there were more yellowfin west of 150°W. The concentration encountered on 170°W. evidently extended at least as far as 180°, for Japanese commercial boats experienced catches averaging over 5 yellowfin per hundred hooks between 170°W. and 180° (fig. 3). During August the highest catches (about 10 per hundred hooks) were made on 155°W. (fig. 2), and poorer fishing (less than 5 per hundred hooks) was found farther west between 160°W. and 180° (figs. 2 and 3), suggesting an eastward shift of the population from its location during May and June. Finally, during December poor catches (about 2 per hundred hooks, with one exception) were had along 155°W. (fig. 2), but there is no information from areas east or west of that longitude so we cannot hazard a guess as to the location of the center of abundance, if one existed, along the Equator at that time.

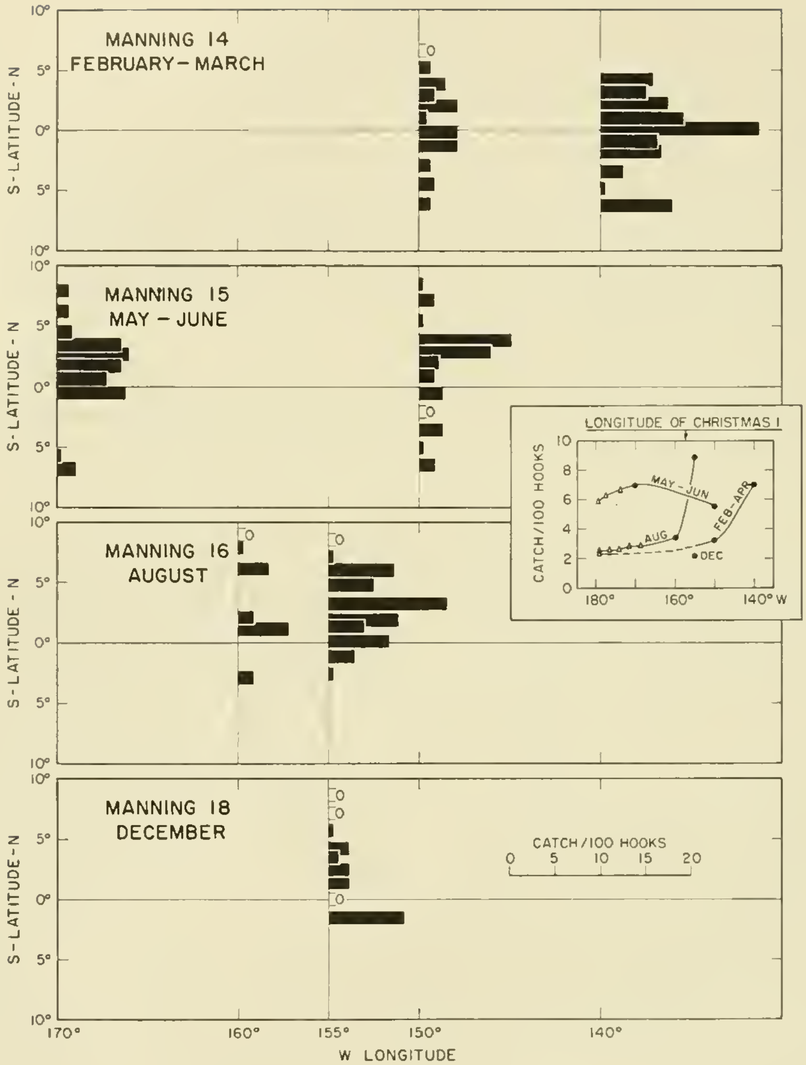

Figure 2.--Temporal and spatial distribution of long-line catches of yellowfin made during 1953 at stations more than 80 miles from land (data from appendix tables 6-11). Insert--diagrammatic representation of longitudinal variation in abundance (data from figs. 2 and 3). The round dots represent POFI data and the triangles represent Japanese data.

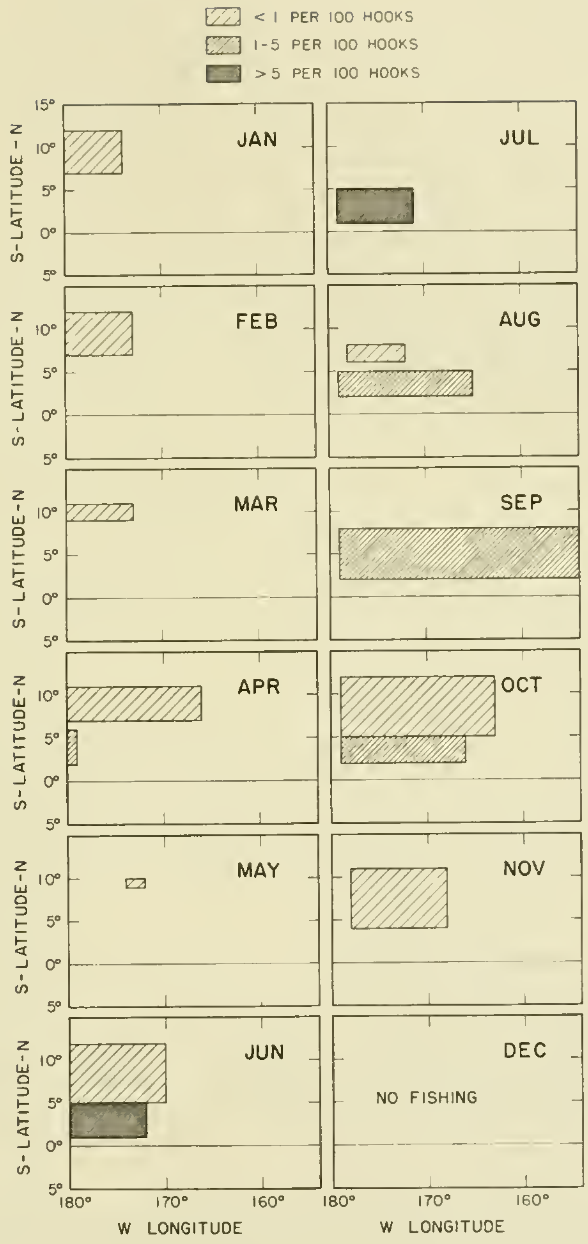

Figure 3.--Japanese commercial yellowfin catches in the central Pacific in 1953 (data from appendix table 12). The rectangles indicate the areas fished and the code indicates the catch rates.

Considering the distribution in relation to latitude, it is evident from figure 2 that during February and March the zone of highest yellowfin abundance straddled the Equator. During the period of May-August the center of abundance lay about 2 degrees north of the Equator (fig. 2). In December there appears to have been a small concentration centered north of the Equator (except for the high catch at a single station south of the Equator). Thus we see that during most times of the year the center of abundance of yellowfin was at or a little north of the Equator. The Japanese commercial fishing results (fig. 3) tend to confirm this conclusion in that they show yellowfin to have been more abundant between the Equator and 5°N. than they were north of that latitude at all seasons in which any fishing was done in these latitudes. The Japanese catches do not lend themselves to more refined analysis because the data received by POFI were averaged by 5 degrees of latitude and there was no fishing south of the Equator.

The temporal changes along longitudes 150°W. and 155°W., the best sampled portions of our study area, are shown in figure 4. In this area the average yellowfin catch during February was small (2.4 per hundred hooks) at a time when good fishing was found farther to the east. Catches were higher during May (averaging 5.5 per hundred hooks), but were smaller than those experienced further west. The highest average yellowfin catch (7.3 per hundred hooks) of the year was attained during August, and during this same period poorer fishing was found to the west. Finally, during December fishing was again poor along 150° W. and 155°W. (1.6 per hundred hooks).

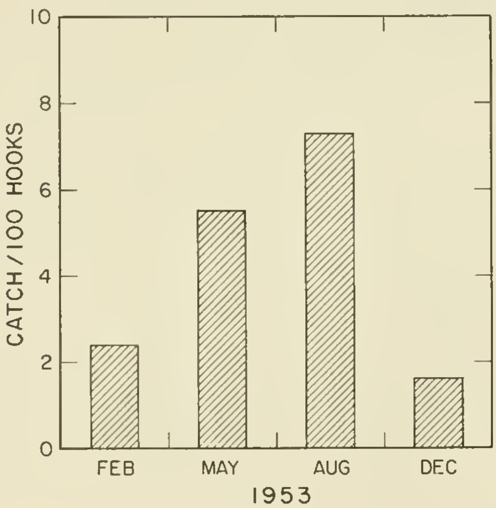

Figure 4.--Temporal variation of yellowfin abundance for stations between the Equator and 5°N. latitude at 150°-155°W. longitude (data from appendix tables 6-11).

Thus there is evidence that there were geographic shifts in the yellowfin population near the Equator with time, but these shifts cannot be precisely described on the basis of the information at hand. In

summary, the pattern revealed by the available catch data suggests that yellowfin were centered over the Equator to the east of 150°W. during February and March. Later in the year, during May and June, they were centered north of the Equator to the west of 150°W. During August they were centered in the general vicinity of 150°W., and during December they were scarce along 150°W. Whether these apparent shifts in abundance are parts of a pattern of regularly recurring annual migrations, or merely transient phenomena possibly associated with changes in the environment during one year is a problem that remains for future study. Some indication that the shifts may be manifestations of a stable pattern, as yet poorly understood, is given by the repeated occurrence of very good fishing along 150°-155°W. longitude during August-September of 1951 and 1952 (Murphy and Shomura 1953a, 1955) and again in 1953.

Other Tunas

The distributions of the other three tunas (bigeye, albacore, and skipjack) differ from that of the yellowfin and among each other. For instance, bigeye catches were sporadic and small in the vicinity of the Equator, where yellowfin were most abundant (fig. 5). Generally bigeye were most abundant north of 5°N. latitude, where yellowfin were scarce. This is also shown in the results of Japanese fishing between 170°W. and 180° (appendix tables 12 and 13). It is worth noting that bigeye are nowhere as abundant as yellowfin, high catches ranging from 2 to 5 per hundred hooks, whereas high yellowfin catches range from 5 to 15 per hundred hooks.

Albacore, unlike both bigeye and yellowfin, were most abundant south of the Equator (fig. 5) with the peak catch at 6°S. on 170°W. This is in general agreement with the results of earlier cruises, when they were found to be most abundant south of the Equator in the western portion (170°W.-180°) of the survey area (Murphy and Shomura 1953b, 1955).

Skipjack were taken sporadically in small numbers throughout the entire area, usually not more than one or two at a station (appendix tables 6 to 11). These catches can hardly be taken as more than an indication of the presence or absence of skipjack, for longlines do not sample this small, surface-schooling species effectively.

Relation of Catches to the Environment

The 1953 longline surveys substantiate earlier findings (Murphy and Shomura 1953a, b, 1955) on the relation of the distribution of deep-swimming tunas to major features of the environment. In general

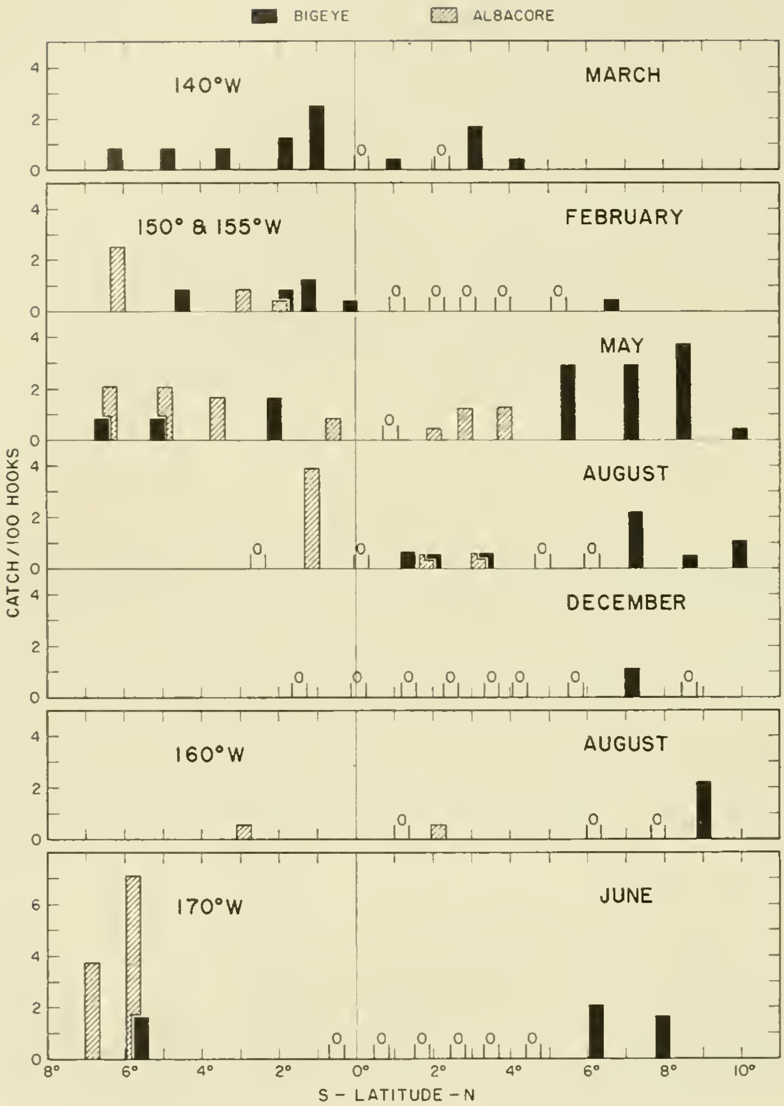

Figure 5.--Temporal and spatial distribution of longline catches of bigeye and albacore in 1953 at stations more than 80 miles from land (data from appendix tables 6-11).

yellowfin were most abundant near the Equator, where enrichment through upwelling results in an augmented supply of plankton (King and Demond 1953) presumably accompanied by an increase in tuna forage. This higher yellowfin abundance near the Equator, as compared with regions to the north and south, is clearly shown by the POFI surveys and by Japanese tuna fishing. Bigeye were more abundant than yellowfin north of the Equator, in the Countercurrent (roughly 5°N. - 10°N. latitude), although the population of bigeye there is not nearly as dense as that of the yellowfin to the south. At the present time the higher catches of albacore south of the Equator and west of 150°W. longitude cannot be associated with any particular feature of the environment.

The temperature sections drawn from bathythermograms taken on each fishing line are shown in figures 13 to 19 (appendix). Each section, except those of <u>Manning</u> cruise 15 (figs. 15 and 16), shows the characteristic features that appear to be associated with the tuna populations. The isotherms sloping downward from about 10° to 5°N. latitude roughly coincide with the easterly flowing Countercurrent, where bigeye are more abundant than yellowfin. South of 5°N. latitude is the westerly flowing South Equatorial Current, where yellowfin are most abundant. Centered approximately at the Equator are the doming isotherms and lower surface temperatures associated with equatorial upwelling. Yellowfin are generally most abundant between the doming and the Countercurrent.

However, during May and June of 1953 the characteristic features of the current system were virtually absent (figs. 15 and 16) along 150°W. and 170°W. longitude. Instead of the well defined slope usually associated with the Countercurrent, the slope was almost imperceptible. The doming at the Equator was also very weak. For instance, the 80°F. isotherm did not reach the surface on 150°W., whereas in all sections before and after this crossing the surface water at the Equator in this area has been cooler than 80°F. These observations suggest a slowing down or stopping of the entire equatorial current system, which was further indicated by the unusually slight drift of the longline on the stations of <u>Manning</u> cruise 15. However, the fishing results (fig. 2) show that this peculiar condition of the circulation did not affect the catches adversely; on the contrary, fishing along 170°W. was better than in our previous experience (Murphy and Shomura 1953b) although it is entirely possible that these events in the environment did affect the distribution of yellowfin at some later time.

Insular Catches

The tuna catches made at insular stations, i.e., those within 80 miles of land, during 1953 (table 2) were mostly yellowfin. These catches suggest that this species tends to be more abundant near land than in the open ocean, e.g., an average catch of 4.3 yellowfin per hundred hooks near Palmyra Island in late January 1953, while at approximately the same time (early February) catches in the open ocean at about the same latitude as Palmyra (5°-6°N.) averaged around 2 per hundred hooks.

Considerably more data are available in the instance of Christmas Island (2°N., 157°W.), where there was more fishing and where comparisons can be made between oceanic fishing (on 150°W. and 155°W. longitude) and insular fishing during several periods of the year (fig. 6). As shown in this figure, seasonal trends for the island fishing closely resembled seasonal trends for adjacent oceanic fishing, but in each instance the island catch was higher. For example, during August fishing was best at Christmas Island (10.9 per hundred hooks) and in the adjacent oceanic area (7.8 per hundred hooks). During January to February catches were low near Christmas Island (4.4 per hundred hooks) and only 2.4 per hundred hooks in the adjacent oceanic areas. As will be shown later, at least part of the higher catch near islands was caused by the addition of small fish to the catches of large deep-swimming yellowfin.

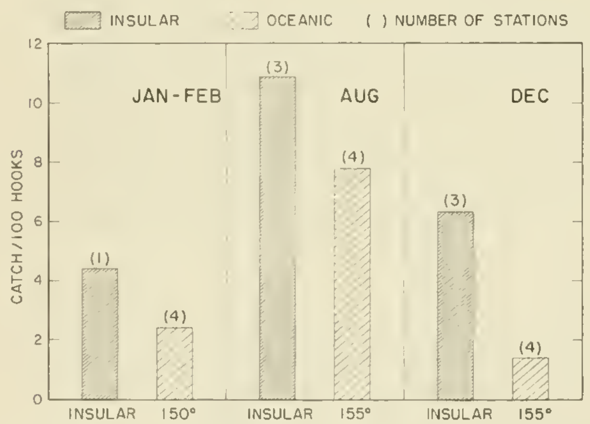

Figure 6.--Comparison of yellowfin catch rates from insular stations (within 80 miles of Christmas Island - 2°N. latitude, 157°W. longitude) and oceanic stations (at 150°-155°W. longitude between the Equator and 4°N. latitude). Data from appendix tables 6-11.

VERTICAL DISTRIBUTION OF TUNAS

In equatorial waters the tunas are not generally taken at the same rate at all depths fished by the longline (Nakamura 1949, Murphy and Shomura 1953a, b, 1955). Considering all of the 1953 data,

Table 2.--Yellowfin catch of insular fishing stations (within 80 miles of land). See appendix, tables 6 to 11, for more complete catch records

Cruise	Station	Yellowfin catch per hundred hooks	Distance from land miles	Approximate station position[1]
Smith 19 (January-February)	53	12.1	13	SW of Palmyra I.
	56	2.9	5	S of Palmyra I.
	58	2.1	8	E of Palmyra I.
	60	0.0	40	E of Palmyra I.
	62	1.2	22	E of Christmas I.
	63	7.5	8	W of Christmas I.
	68	4.6	12	SW of Fanning I.
Manning 14 (February-March)	22	0.4	65	SW of Matahiva I.
	24	2.9	70	NW of Ahe I. (Tuamotu Archipelago)
Manning 15 (May-June)	19	6.2	60	E of Sydney I.
	20	0.8	30	NE of Phoenix I.
	21	2.1	80	NE of Enderbury I. (Phoenix Islands)
Manning 16 (August)	12	6.1	60	E of Christmas I.
	13	16.1	17	NE of Christmas I.
	14	10.6	10	NW of Christmas I.
	20	2.8	30	SW of Malden I.
	22	9.4	65	S of Jarvis I.
	23	3.3	25	N of Jarvis I.
	26	1.1	70	SW of Fanning I.
	27	4.4	22	E of Washington I.
Manning 17 (October-November)	2	7.2	44	NE of Christmas I.
	3	5.6	15	NE of Christmas I.
	4	10.3	21	NNW of Christmas I.
	5	12.5	42	NNW of Christmas I.
	6	7.0	46	S of Christmas I.
	7	11.4	20	S of Christmas I.
Manning 18 (December)	2	3.3	30	S of Malden I.
	5	2.2	60	N of Malden I.
	16	2.8	63	E of Christmas I.
	18	13.3	20	NE of Christmas I.
	19	2.8	45	W of Christmas I.

[1] Islands otherwise unspecified are in the Line Islands group

yellowfin were taken in somewhat greater numbers on the deeper hooks, while albacore and bigeye were taken in markedly greater numbers on the deeper hooks.

As we were not able to determine reliably the absolute depth of the line during 1953, the distribution of the catches must be considered in terms of relative depth (see Murphy and Shomura 1955 for a summary of the measurements of absolute depth). We have separated the catches by relative depth by dividing the line into three levels, each occupied by two hooks that fish at the same level if the sag of the line forms a symmetrical curve. The records for the individual cruises in 1953 show that yellowfin were usually, but not always, taken in greater numbers on the deepest or on the two deeper levels (table 3). The catch of bigeye and albacore was always poor on the shallowest hooks, and usually best on the deepest hooks (table 3).

The difference in catch with depth is probably the result of at least three factors. In the Pacific, albacore and bigeye are taken in substantial numbers farther north and in cooler water than yellowfin and thus in the tropics these two species might be expected to be taken in greater numbers on hooks fishing the deeper, cooler strata. Secondly, King and Ikehara (MS) found slightly more food in the stomachs of yellowfin and bigeye taken on deeper hooks, suggesting that food is more available in the deeper levels fished by the gear. A complication is the tendency for more baits to remain on the deeper hooks through the fishing period (Shomura 1955). This latter cannot be the only cause of increased catch with depth, however, for the difference in bait retention is not as great as the difference in catch, and differences in bait effectiveness with depth can hardly explain the variation in catch with depth among the three species. The conclusion is that temperature preference and abundance of food are probably the most important factors associated with variation in the vertical distribution of deep-swimming tunas in the equatorial Pacific.

SIZE COMPOSITION OF THE CATCHES OF TUNA

Yellowfin

The size composition of longline-caught yellowfin is in part a function of the nearness of land. This is shown when the 1953 catches are grouped into those made within 80 miles of land and those made farther from land (fig. 7). This separation, the same as that made when considering abundance in an earlier section, clearly points up

Table 3.--Tuna catch by relative hook depth, 1953 (data from standard 6-hook gear only)

Cruise	Shallow hooks (hooks 1 and 6)	Intermediate hooks (hooks 2 and 5)	Deep hooks (hooks 3 and 4)
Yellowfin			
Manning 14	74	80	73
Smith 19	38	36	42
Manning 15	47	68	79
Manning 16	40	82	80
Manning 17	18	21	30
Manning 18	11	23	40
Total	228	310	344
Bigeye			
Manning 14	5	12	14
Smith 19	1	-	-
Manning 15	4	18	23
Manning 16	5	3	9
Manning 17	-	-	3
Manning 18	-	-	3
Total	15	33	52
Albacore			
Manning 14	-	9	22
Smith 19	-	-	-
Manning 15	7	28	28
Manning 16	2	3	12
Manning 17	1	2	1
Manning 18	-	-	1
Total	10	42	64
Skipjack			
Manning 14	6	7	8
Smith 19	-	-	-
Manning 15	6	4	5
Manning 16	2	-	4
Manning 17	1	-	-
Manning 18	1	2	-
Total	16	13	17

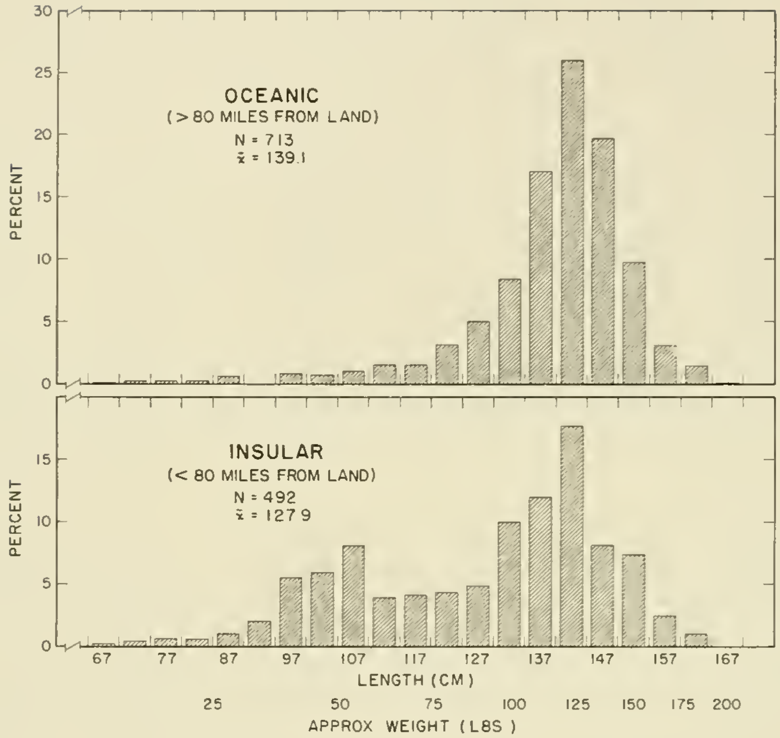

Figure 7.--Yellowfin size distribution with distance from land (data in appendix table 14).

the greater number of small fish (around 100 cm. = 43 lbs.) near land, while the major mode of large fish is at 142 cm. (123 lbs.) in both instances.

If the 1953 catches are arranged by longitude of capture (fig. 8), the size composition is virtually the same for 140°W., 150°W., and 160°W. (modes at 142 cm. = 123 lbs.), excepting that a few more small fish were captured to the west. Contrasting with this uniformity is the sample from 170°W., where the major mode is some 5 cm. less (137 cm. = 110 lbs.) (fig. 8).

Yellowfin captured on 150°-155°W., when arranged by time of year (fig. 9), show that the size composition did not change materially through 1953, except for the appearance of more small fish in the catches made during the last half of the year. Even this change may merely reflect distance from land, for the latter two samples are from 155°W., 300 miles closer than 150°W. longitude to the Line Islands, where small yellowfin are comparatively abundant.

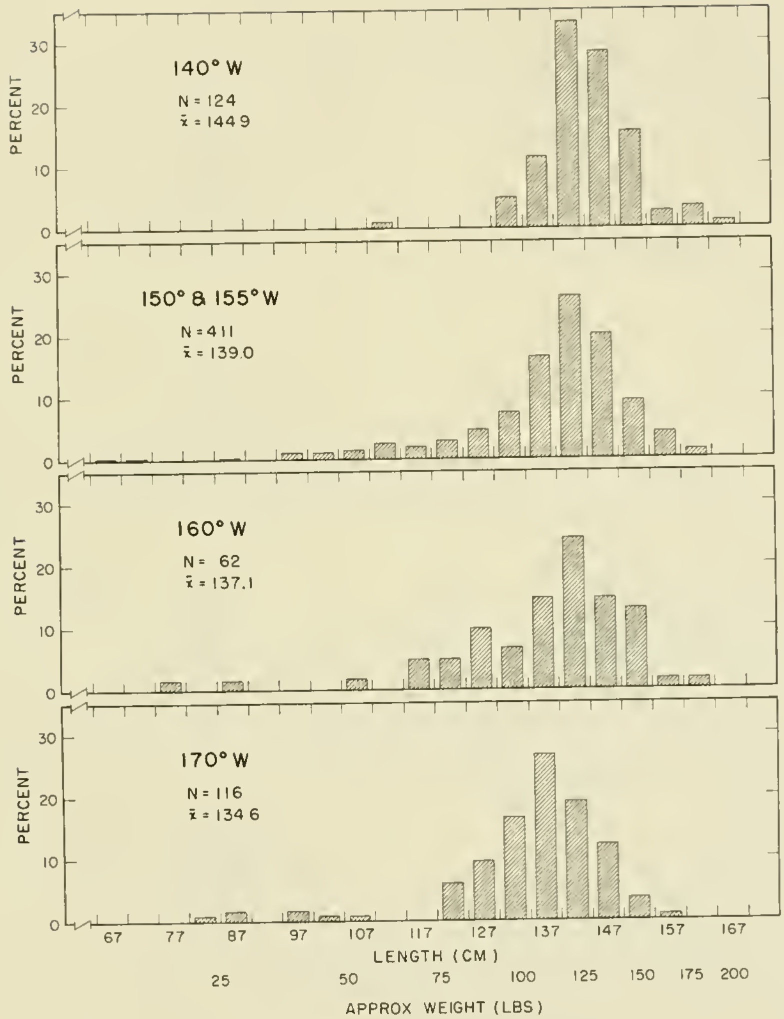

Figure 8.--Yellowfin size distribution by longitude (data in appendix table 14).

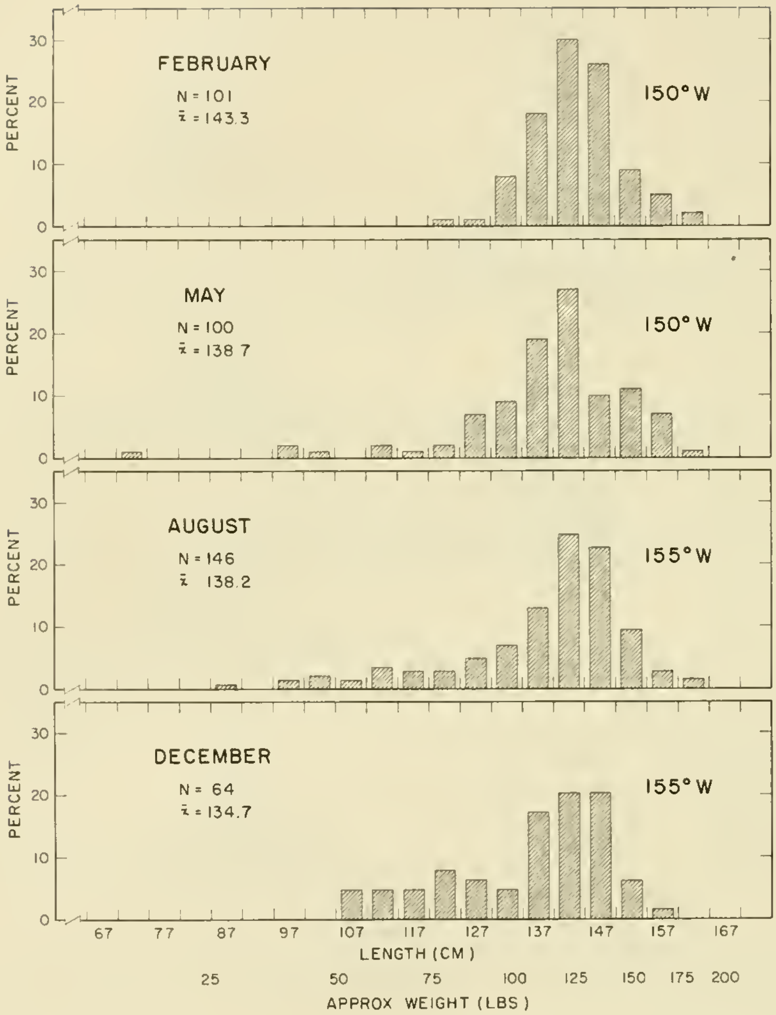

Figure 9.--Yellowfin size distribution by time of year at 150°-155°W. longitude (data in appendix table 14).

Other Tunas

The numbers of bigeye, albacore, and skipjack taken during 1953 were too small to warrant detailed analysis. As a whole (fig. 10) they were similar in size to our past catches on the longline in the equatorial central Pacific. About 90 percent of the bigeye were 122-172 cm. in length (85-232 lbs.), of the albacore 91-103 cm. (36-51 lbs.), and of the skipjack 70-81 cm. (18-29 lbs.).

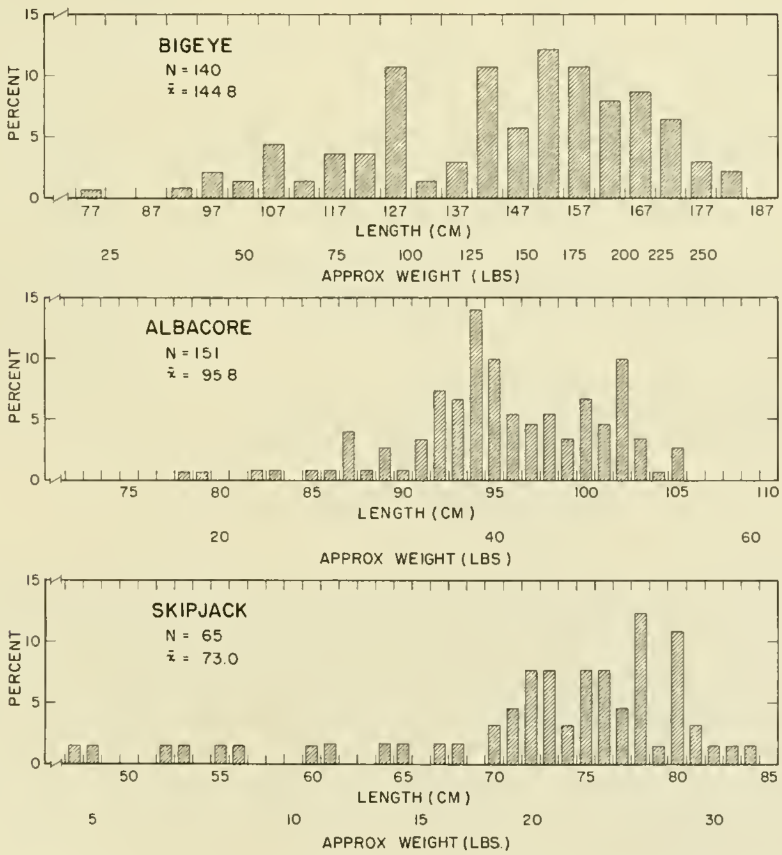

Figure 10.--Size distribution of other tunas (data in appendix table 15).

SEX COMPOSITION OF THE TUNA CATCHES

There was a preponderance of males among the yellowfin taken during 1953. As in past samples (Murphy and Shomura 1955), the sexes were about equally represented in the 1953 yellowfin catches up to 137 cm. (110 lbs.), and above this size males clearly predominated (fig. 11).

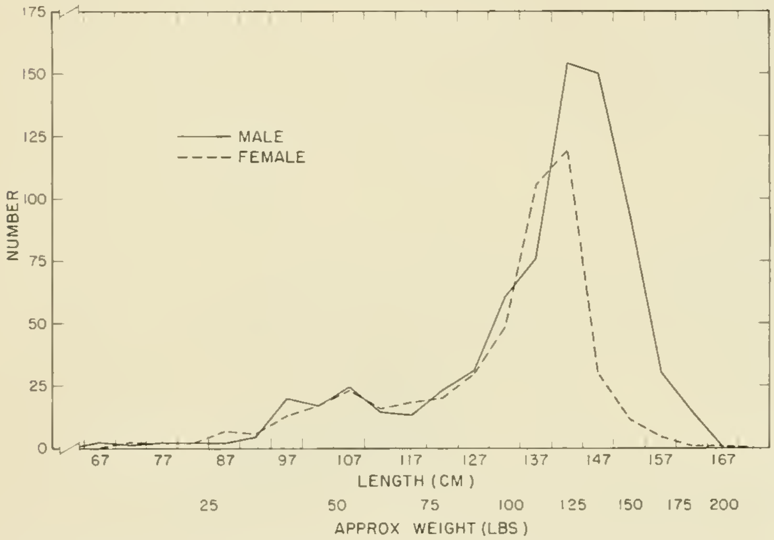

Figure 11.--Yellowfin size distribution by sex, 1953 (data in appendix table 15).

The bigeye (fig. 12) also showed an unbalanced sex ratio but the 1953 samples include too few fish to yield a satisfactory description. There is a tendency, however, for males to dominate among fish larger than 122 cm. (85 lbs.). Among the larger albacore, males definitely dominate (fig. 12), but again the samples are too small to describe the sex ratio adequately at all sizes. Of the 66 skipjack taken in 1953, 30 were females, and there was about even representation throughout the lengths captured (47-85 cm. = 5-34 lbs.).

CHANGES IN LONGLINE GEAR

Three basic innovations were made to the longline gear during 1953 (Mann MS). The first was shortening the droppers in order to reduce construction costs and handling labor. The second was the insertion in the mainline of a wire link to which the dropper is snapped, an improvement designed to reduce the number of tangles. Finally, an attempt was made to discover the optimum hook spacing along the mainline. These changes are interrelated and their development was to some extent simultaneous, but for the sake of clarity we will consider each separately.

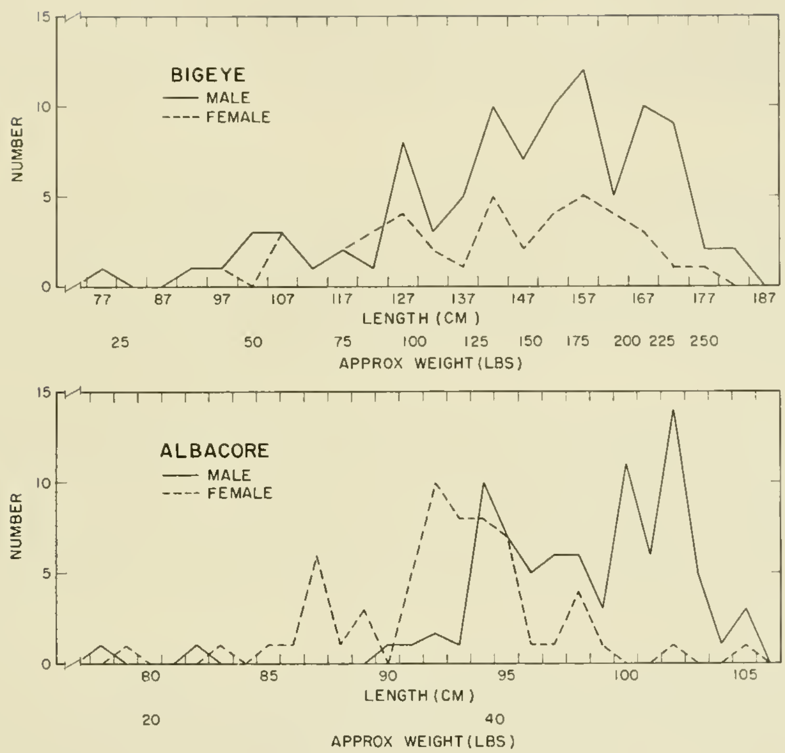

Figure 12.--Bigeye and albacore size distribution by sex, 1953 (data in appendix table 15).

Improvements in Construction

Experience with longline gear equipped with six 11-fathom droppers (10 fathoms of cotton and 1 fathom of leader) per basket suggested that much labor during hauling and considerable fabrication expense would be saved if the droppers could be shortened without reducing the catch. Accordingly, droppers consisting of 1 fathom of 261-thread cotton line and 1 fathom of leader were tested on two cruises.

During the first experiment 20 baskets of short-dropper gear were fished at each of 12 stations. The total catch on this gear was

88 fish including all species, and 82 fish were taken on the adjacent 20 baskets of long-dropper gear. During the second experiment 10 baskets of short-dropper gear were fished on each of six stations. The total catch was 46 on the special gear and 34 on the regular gear. Although the design of these experiments did not provide perfect statistical control of soaking time, the results suggested that short droppers were as efficient as long ones as far as catching fish is concerned.

Shortening the droppers did not actually reduce the labor during the hauling, however, for the short droppers tended to tangle (wrap around the mainline) more than the long droppers. This is reflected in the average hauling time of 4.0 minutes for short-dropper gear compared to 3.6 minutes for baskets equipped with long droppers fished at the same time.

Excessive tangling of short droppers was virtually eliminated by introducing a wire link in the mainline. Each dropper is snapped on this link or bridle, which turns freely in the AK snap, and thus the dropper is rarely wrapped on the mainline when the latter twists, as it frequently does when under tension. This was shown quantitatively during three cruises when wire bridles were used. Of 1,181 baskets with 11 short droppers (2 fathoms of cotton and 1 fathom of leader) and wire links, 86 percent had one or no tangle, while of 1,433 baskets with 6 long droppers and no links only 63 percent had one or no tangle. Reduced tangling is also reflected in the hauling time, for 11-hook gear with wire links was hauled in an average of 3.7 minutes per basket over the three cruises, while the regular 6-hook gear (fished at the same stations) averaged 3.9 minutes per basket (excluding baskets with broken mainlines).

Changes in Hook Spacing

Changes in hook spacing along the mainline were initiated in 1953 in order (1) to ascertain the most efficient hook spacing from operational (i.e., commercial) aspects, and (2) to provide additional information on the schooling behavior of the fish. Analysis of the catches of 6-hook gear (Murphy and Elliott 1954) suggested that yellowfin were schooled, and if this were true, the catch over a given unit of line should be greater if more hooks are available to the schools of fish that encounter a segment of line. These experiments are continuing, so this discussion must be considered a preliminary report.

In each of the experiments described below, standard gear with 6 hooks, 30 fathoms apart, on a 210-fathom mainline was used as a control. The 11-hook experimental gear differed from the standard gear in having an extra hook between each of the original hooks and in having all short droppers (3 fathoms overall) which were attached to wire bridles in the mainline. These innovations made interpretation of the hook spacing results a little complex and imprecise, but time was not available to test each variable in turn.

The first experiment involving closer hook spacing was primarily a test of (1) the wire links discussed above, and (2) the practicability of spacing droppers closer together. During the test, 10 baskets of experimental gear with 11 hooks, 15 fathoms apart, were appended to the end of sets of 40 baskets of standard gear with 6 hooks, 30 fathoms apart, at each of 26 stations (Manning cruise 15). The 11-hook gear performed satisfactorily from a mechanical point of view and took 73 yellowfin. This compares very favorably (1.43x) with the catch of 51 yellowfin on the adjacent 10 baskets of 6-hook gear. The 11-hook gear was on the end of the set, however, and fished about 10 percent longer than the adjacent 6-hook gear, which may have accounted for a portion of the larger catch.

The catch rates on 11- and 6-hook gear from subsequent experiments may be compared directly because fishing time was controlled by alternating the gear along the entire set. Usually the 6- and 11-hook baskets were alternated in groups of five. A summary of the results of three experiments is shown in table 4. During these cruises the 11-hook gear took 1.21x the catch of the 6-hook gear, something less than the hook ratio 11/6 (1.83x).

Table 4.--Comparison of the catches of 6- and 11-hook gear

Cruise	Number of stations	6-hook		11-hook	
		Number of baskets	Yellowfin	Number of baskets	Yellowfin
Manning 16	26	775	202	507	162
Manning 17	6	139	72	139	76
Manning 18	14	420	76	420	99
Total	46	1334	350	1066	337
Number per basket			0.262		0.316

An operational trial of 21-hook gear (branch lines 7.5 fathoms apart) was conducted at 18 stations on Manning cruise 16. This experiment consisted of appending 10 baskets of 21-hook gear to the longest fishing end of sets of mixed 6- and 11-hook gear. The results at two stations were complicated by the presence of land, and on four stations no yellowfin were taken. On the remaining 12 stations the 21-hook gear caught 71 yellowfin, the nearest 8 baskets of 11-hook gear caught 21 yellowfin, and the nearest 12 baskets of 6-hook gear took 53 yellowfin. The respective catches per basket were 0.68 for 21-hook, 0.22 for 11-hook, and 0.37 for 6-hook. These data suggest that the catch per basket can be increased over that given by the 11-hook gear, but it is also evident that sampling was inadequate and that fishing time was not equal, for the 21-hook gear was in the water longest.

Spacing the hooks closer together, at intervals of about 15 fathoms, appears to be advantageous to commercial fishermen. The additional cost of adding 5 droppers to the normal 6-hook gear is so small that a decision would appear to hinge on the speed of hauling. Experimental data are not available, but the increase in hauling time due to extra hooks can be inferred from time studies on the 11-hook gear.

In the absence of tangles one basket of 11-hook gear is hauled in about $3^{m}\ 00^{s}$. On the average about 3 seconds is required to remove a dropper (time from stop to start of the hauler). Extrapolating we estimate that 6-hook gear with wire links would have been hauled in $2^{m}\ 45^{s}$. The 11-hook gear then takes 1.09 times as long to haul, and our information to date indicates that it catches 1.21 times as many yellowfin.

Another factor to be considered, however, is the tendency for more branch lines to break or be lost when using the 11-hook gear with the wire sections. For instance 559 baskets of 6-hook gear (3,354 branch lines) suffered 25 broken branch lines. At the same time 559 baskets of 11-hook gear (6,149 branch lines) suffered 66 broken branch lines. The percent of failure is 0.75 in the 6-hook gear and 1.01 in 11-hook gear, indicating that design changes that reduce branch line failures will further increase the catch of 11-hook gear relative to that of the 6-hook gear.

In summary, it appears that the Japanese-type gear on which POFI based its 6-hook baskets has been substantially improved by innovations in construction and by spacing hooks closer together.

Abandoning the sekiyama (Murphy and Shomura 1955, Mann MS) and shortening droppers reduced the cost of fabrication. Introducing the wire mainline section reduced tangling and therefore the amount of labor during hauling. Spacing branch lines 15 fathoms apart instead of 30 fathoms increased the catch more than it increased the labor. It is equally clear that many development problems remain, e.g., reducing the incidence of dropper failure and determining the optimum hook spacing.

SHARK DAMAGE TO TUNA CATCHES

During the period the longline is in the water (5 to 10 hours) a portion of the tuna catch is damaged by sharks. This damage, summarized in table 5, suggests that commercial operators can expect to lose about 20 percent of their catches when fishing in the central equatorial Pacific.

Table 5.--Summary of shark-bitten tuna, 1953 (includes catches made on all types of gear and excludes results of special stations)

Cruise	Yellowfin		Bigeye		Albacore		Skipjack		Grand total	
	Total catch	Percent shark-bitten	Total catch	Percent shark-bitten	Total catch	Percent shark-bitten	Total catch	Percent shark-bitten	Total catch	Percent shark-bitten
Manning 14	276	20.7	34	14.7	39	0.0	28	7.1	377	17.0
Smith 19	127	33.9	1	0.0	-	-	1	0.0	129	33.3
Manning 15	270	10.7	57	12.3	98	14.3	22	13.6	447	11.9
Manning 16	466	22.5	51	11.8	31	19.4	15	6.7	563	21.0
Manning 17	149	16.1	6	16.7	4	25.0	4	0.0	163	16.0
Manning 18	171	22.8	8	25.0	2	50.0	6	16.7	187	23.0
Total	1459	20.4	157	13.4	174	12.6	76	9.2	1871[1/]	18.8

1/ Includes 5 unidentified, badly shark-bitten tunas

SUMMARY

1. The Pacific Oceanic Fishery Investigations conducted six longline cruises in the equatorial region of the Pacific between 140°W. and 170°W. longitude during 1953.

2. The catches experienced during the several crossings of the equatorial current system were consistent with earlier findings. Yellowfin were found most abundant in the region near the Equator which is enriched by upwelling. Bigeye were most abundant in the region of the Countercurrent, and albacore most abundant south of the Equator.

3. The results suggest that the longitude of best catch shifted during the year, and that east-west movements recur from year to year.

4. Catches around Christmas Island were higher than in the open ocean, at least in part because small "surface yellowfin" were taken in addition to the large deep-swimming yellowfin.

5. Yellowfin were usually taken in greater numbers on the deeper hooks of the longline. Bigeye and albacore catches exhibited this tendency more markedly than those of yellowfin.

6. During 1953 more small yellowfin were taken near islands than offshore. The size of oceanic yellowfin was uniform from 140°W. to 160°W. longitude, but specimens from 170°W. were smaller. The size of the yellowfin taken at 150°-155°W. longitude did not change materially throughout the year.

7. Males predominated among the larger yellowfin, bigeye, and albacore.

8. Short droppers (2-3 fathoms) appeared to be as efficient as long branch lines (10 fathoms), except for a tendency to break more often.

9. The use of wire links in the mainline, to which branch lines are attached, materially reduced the number of tangles.

10. Increasing the number of branch lines on 1,260 feet of mainline from 6 to 11 increased the catch about 21 percent. This increase was greater than the additional hauling time imposed by the added branch lines.

11. Shark damage to the tuna catch averaged 18.8 percent.

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APPENDIX

Table 6.--Manning cruise 14, summary of the tuna catch on 6-hook gear (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

Station	Date	Noon position		Number of hooks	Catch per 100 hooks				
		Latitude	Longitude		YF	BE	Alb.	SJ	Total 1/
1	1-23-53	20°52'N.	157°18'W.	234	-	-	-	-	-
2	1-26-53	15°46'N.	154°13'W.	240	-	0.42	-	-	0.42
3	1-28-53	12°20'N.	151°47'W.	240	-	-	-	-	-
4	1-31-53	06°38'N.	150°12'W.	228	-	0.44	-	-	0.44
5	2-1-53	05°15'N.	149°55'W.	240	1.25	-	-	0.42	1.67
6	2-2-53	03°49'N.	150°07'W.	240	2.92	-	-	-	2.92
7	2-3-53	02°54'N.	150°25'W.	240	1.67	-	-	0.83	2.50
8	2-4-53	02°06'N.	150°09'W.	234	4.27	-	-	0.43	4.70
10	2-10-53	01°04'N.	151°05'W.	240	0.83	-	-	-	0.83
11	2-11-53	00°09'S.	150°03'W.	240	4.17	0.42	-	1.25	5.83
12	2-12-53	01°13'S.	150°11'W.	240	4.17	1.25	-	-	5.83 2/
17	2-16-53	01°55'S.	150°07'W.	240	-	0.83	0.42	0.83	2.08
18	2-17-53	02°56'S.	150°12'W.	240	1.25	-	0.83	-	2.08
19	2-18-53	04°29'S.	150°16'W.	240	1.67	0.83	-	-	2.50
20	2-19-53	06°08'S.	150°09'W.	240	1.25	-	2.50	0.42	4.17
21	2-21-53	11°27'S.	149°47'W.	240	1.25	-	1.25	-	2.50
22	2-23-53	15°32'S.	149°34'W.	240	0.42	-	1.25	-	1.67
24	3-4-53	13°31'S.	147°08'W.	240	2.92	-	2.08	-	5.42 2/
25	3-6-53	10°09'S.	144°31'W.	240	0.83	0.42	4.58	-	5.83
26	3-8-53	06°16'S.	141°32'W.	240	7.92	0.83	-	-	8.75
27	3-9-53	04°52'S.	140°36'W.	240	0.42	0.83	-	1.67	2.92
28	3-10-53	03°25'S.	140°03'W.	240	2.50	0.83	-	0.42	3.75
29	3-11-53	01°48'S.	139°59'W.	240	6.67	1.25	-	-	7.92
32	3-13-53	01°00'S.	140°05'W.	240	6.25	2.50	-	-	8.75
33	3-14-53	00°09'N.	139°47'W.	240	17.50	-	-	0.83	18.33
34	3-15-53	01°00'N.	140°00'W.	240	9.17	0.42	-	0.42	10.00
35	3-16-53	02°14'N.	140°18'W.	240	7.50	-	-	-	7.50
36	3-17-53	03°07'N.	140°07'W.	240	5.00	1.67	-	0.83	7.50
37	3-18-53	04°12'N.	140°20'W.	240	5.83	0.42	-	0.42	6.67

1/ Calculated independently

2/ Includes one unidentified, shark-bitten tuna

Table 7.--Smith cruise 19, summary of the tuna catch on 6-hook gear

Station	Date	Noon position		Number of hooks	Catch per 100 hooks		
		Latitude	Longitude		Yellowfin	Bigeye	Total 1/
53	1-23-53	05°49'N.	162°22'W.	240	12.08	-	12.08
56	1-25-53	05°48'N.	162°07'W.	240	2.92	-	2.92
58	1-26-53	05°54'N.	161°52'W.	240	2.08	-	2.08
60	1-27-53	05°54'N.	161°20'W.	240	-	-	-
62	1-31-53	01°44'N.	156°47'W.	240	1.25	-	1.25
63	2-1-53	01°50'N.	157°40'W.	240	7.50	-	7.50
68	2-5-53	03°46'N.	159°33'W.	240	4.58	0.42	5.00

1/ Calculated independently

Table 8.--Manning cruise 15, summary of the tuna catch on 6-hook gear (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

Station	Date	Noon position		Number of hooks	Catch per 100 hooks				
		Latitude	Longitude		YF	BE	Alb.	SJ	Total[1/]
1	4-29-53	19°38'N.	156°15'W.	240	-	-	-	-	-
2	5-3-53	09°57'N.	151°07'W.	240	-	0.42	-	-	0.42
3	5-4-53	08°31'N.	150°17'W.	240	0.42	3.75	-	-	4.17
5	5-5-53	07°08'N.	150°06'W.	240	1.67	2.92	-	-	4.58
6	5-6-53	05°30'N.	150°00'W.	240	0.42	2.92	-	-	3.33
7	5-7-53	03°52'N.	150°05'W.	234	10.26	-	1.28	1.28	12.82
8	5-8-53	02°50'N.	150°04'W.	240	7.92	-	1.25	0.42	9.58
10	5-10-53	02°02'N.	149°55'W.	240	2.08	-	0.42	0.42	2.92
11	5-11-53	00°54'N.	149°46'W.	240	1.67	-	-	-	1.67
12	5-12-53	00°36'S.	150°07'W.	240	2.50	-	0.83	0.42	3.75
13	5-13-53	02°06'S.	150°06'W.	240	-	1.67	-	0.83	2.50
14	5-14-53	03°35'S.	150°02'W.	240	2.50	-	1.67	-	4.17
15	5-15-53	05°03'S.	150°04'W.	240	0.42	0.83	2.08	-	3.33
16	5-16-53	06°28'S.	150°00'W.	240	1.67	0.83	2.08	0.42	5.00
17	5-28-53	06°51'S.	170°02'W.	240	2.08	-	3.75	-	5.83
18	5-29-53	05°41'S.	169°44'W.	240	0.42	1.67	7.08	0.83	10.00
19	5-30-53	04°26'S.	170°09'W.	240	6.25	-	2.08	-	8.33
20	5-31-53	03°27'S.	170°12'W.	246	0.81	0.41	2.85	-	4.06
21	6-1-53	02°14'S.	170°00'W.	240	2.08	-	0.83	0.42	3.33
22	6-2-53	00°30'S.	169°52'W.	240	7.50	-	-	0.42	7.92
23	6-3-53	00°38'N.	169°57'W.	240	5.42	-	-	-	5.42
24	6-4-53	01°43'N.	169°59'W.	240	7.08	-	-	-	7.08
25	6-5-53	02°38'N.	169°59'W.	240	7.92	-	-	0.42	8.33
26	6-6-53	03°30'N.	170°09'W.	240	7.08	-	-	-	7.08
27	6-7-53	04°34'N.	170°11'W.	240	1.67	-	-	-	1.67
28	6-8-53	06°13'N.	170°07'W.	240	1.25	2.08	-	0.42	3.75
29	6-9-53	07°57'N.	169°48'W.	240	1.25	1.67	-	-	2.92

1/ Calculated independently

Table 9.--*Manning* cruise 16, summary of the tuna catch on 6-hook gear (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

Station	Date	Noon position		Number of hooks	Catch per 100 hooks				
		Latitude	Longitude		YF	BE	Alb.	SJ	Total 1/
1	7-25-53	20°47'N.	157°26'W.	174	-	-	-	-	-
2	7-29-53	09°57'N.	155°06'W.	186	-	1.08	-	-	1.08
4	7-30-53	08°39'N.	154°57'W.	192	-	0.52	-	-	0.52
6	7-31-53	07°15'N.	155°04'W.	180	0.56	2.22	-	0.56	3.33
8	8-1-53	06°06'N.	154°49'W.	180	7.22	-	-	-	7.22
9	8-2-53	04°49'N.	155°10'W.	180	5.00	-	-	0.56	5.55
10	8-3-53	03°15'N.	154°59'W.	168	13.10	0.60	0.60	-	14.29
11	8-4-53	01°55'N.	155°21'W.	180	7.78	0.56	0.56	-	8.89
12	8-5-53	02°06'N.	156°13'W.	180	6.11	1.11	0.56	-	7.78
13	8-6-53	02°09'N.	157°04'W.	174	16.09	-	0.56	-	16.67
14	8-7-53	02°05'N.	157°38'W.	180	10.56	-	-	-	10.56
16	8-12-53	01°21'N.	155°16'W.	156	3.85	0.64	-	-	4.49
17	8-13-53	00°08'N.	154°51'W.	180	6.67	-	-	0.56	7.22
18	8-14-53	01°08'S.	155°18'W.	180	2.78	-	3.89	-	6.67
19	8-15-53	02°33'S.	155°23'W.	180	0.56	-	-	-	0.56
20	8-16-53	04°10'S.	155°33'W.	180	2.78	-	0.56	-	3.33
21	8-18-53	02°56'S.	160°14'W.	180	1.67	-	0.56	-	2.22
22	8-19-53	01°31'S.	159°53'W.	180	9.44	0.56	1.67	-	11.67
23	8-20-53	00°01'S.	159°56'W.	180	3.33	-	-	0.56	3.89
24	8-21-53	01°11'N.	160°08'W.	180	5.56	-	-	-	5.56
25	8-22-53	02°08'N.	160°24'W.	180	1.67	-	0.56	-	2.22
26	8-23-53	03°22'N.	160°24'W.	180	1.11	-	-	-	1.11
27	8-24-53	04°43'N.	160°00'W.	180	4.44	-	-	-	4.44
28	8-25-53	06°10'N.	160°02'W.	180	3.33	-	-	0.56	3.89
29	8-26-53	07°50'N.	159°24'W.	180	0.56	-	-	-	0.56
30	8-27-53	09°00'N.	159°40'W.	180	-	2.22	-	0.56	2.78

1/ Calculated independently

Table 10.--*Manning* cruise 17, summary of the tuna catch on 6-hook gear (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

Station	Date	Noon position		Number of hooks	Catch per 100 hooks				
		Latitude	Longitude		YF	BE	Alb.	SJ	Total[1/]
2	10-27-53	02°26'N.	156°42'W.	180	7.22	0.56	-	-	7.78
3	10-28-53	02°06'N.	157°04'W.	180	5.56	-	-	-	5.56
4	10-29-53	02°05'N.	157°50'W.	126	10.32	-	-	-	10.32
5	10-30-53	02°15'N.	158°09'W.	120	12.50	1.67	1.67	0.83	16.67
6	10-31-53	00°54'N.	157°26'W.	114	7.02	-	0.88	-	7.89
7	11-1-53	01°29'N.	157°36'W.	114	11.40	-	0.88	-	12.28

1/ Calculated independently

Table 11.--*Manning* cruise 18, summary of the tuna catch on 6-hook gear (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

Station	Date	Noon position		Number of hooks	Catch per 100 hooks				
		Latitude	Longitude		YF	BE	Alb.	SJ	Total[1/]
2	12-1-53	04°33'S.	155°08'W.	180	3.33	-	0.56	-	3.89
5	12-2-53	03°02'S.	155°12'W.	180	2.22	0.56	-	-	2.78
8	12-3-53	01°28'S.	155°28'W.	180	8.33	-	-	-	8.33
10	12-4-53	00°03'N.	155°15'W.	180	-	-	-	-	-
12	12-5-53	01°22'N.	155°18'W.	180	2.22	-	-	0.56	2.78
14	12-6-53	02°27'N.	155°26'W.	180	2.22	-	-	-	2.22
16	12-7-53	01°59'N.	156°09'W.	180	2.78	-	-	0.56	3.33
18	12-8-53	02°14'N.	157°08'W.	180	13.33	-	-	-	13.33
19	12-9-53	02°01'N.	158°15'W.	180	2.78	-	-	-	2.78
21	12-11-53	03°31'N.	155°23'W.	180	1.11	-	-	-	1.11
23	12-12-53	04°14'N.	154°56'W.	180	2.22	-	-	-	2.22
25	12-13-53	05°42'N.	154°57'W.	180	0.56	-	-	-	0.56
27	12-14-53	07°09'N.	155°00'W.	180	-	1.11	-	0.56	1.67
29	12-15-53	08°38'N.	155°04'W.	180	-	-	-	-	-

1/ Calculated independently

Table 12. --Results of Japanese commercial tuna fishing in the central Pacific during 1953 (data from Nomura et al. 1953)

Month	Latitude	Longitude	Number of hooks	Average catch per 100 hooks						
				Yellow-fin	Big-eye	Alba-core	Skip-jack	Spear-fish[1/]	Sharks	Misc.
Jan.	7°-12°N.	180°-174°W.	384,515	0.41	2.67	0.11	0.04	0.39	0.47	-
Feb.	7°-12°N.	180°-173°W.	265,365	0.31	2.51	0.08	0.03	0.30	0.52	0.04
March	9°-11°N.	180°-173°W.	196,360	0.65	2.03	0.08	0.08	0.44	0.44	0.15
April	7°-11°N.	180°-166°W.	226,221	0.48	2.02	0.02	0.05	0.55	0.17	-
	2°-6°N.	180°-179°W.	38,500	2.75	0.62	-	-	0.78	-	-
May	9°-10°N.	174°-172°W.	24,500	0.38	2.74	0.01	0.17	0.68	1.07	-
June	5°-12°N.	180°-170°W.	95,135	0.63	2.36	0.05	0.12	0.64	0.04	-
	1°-5°N.	180°-172°W.	206,905	5.48	0.92	0.34	0.04	0.62	0.04	-
July	1°-5°N.	179°-171°W.	111,650	5.29	0.95	0.27	0.07	0.74	0.36	-
Aug.	6°-8°N.	178°-172°W.	194,220	0.86	1.84	0.04	0.06	1.07	-	<0.01
	2°-5°N.	179°-165°W.	318,760	2.87	0.91	0.09	0.05	1.13	-	-
Sept.	4°-8°N.	179°-154°W.	100,055	1.18	1.66	0.03	0.10	1.01	0.08	0.14
	2°-7°N.	179°-154°W.	230,155	2.58	0.86	0.28	-	0.80	0.02	0.09
	2°-8°N.	179°-154°W.	330,210	2.15	1.10	0.20	0.10	0.96	0.04	0.10
Oct.	5°-12°N.	179°-163°W.	253,412	0.87	1.04	0.05	-	0.74	0.09	-
	2°-5°N.	179°-166°W.	238,755	2.41	0.57	0.54	-	0.50	0.21	<0.01
Nov.	4°-11°N.	178°-168°W.	143,050	0.81	1.19	0.01	-	0.31	0.16	0.15
Dec.	No fishing east of 180° longitude in central Pacific waters.									

1/ Includes black marlin, white marlin, striped marlin, broadbill, sailfish

Table 13.--Results of Japanese exploratory tuna fishing in the central Pacific during 1953 (data from Iwate Prefecture 1953)

Station	Date	Position		Number of hooks	Catch per 100 hooks			
		Latitude	Longitude		Yellow-fin	Big-eye	Alba-core	Skip-jack
1	4-4-53	11°10'N.	176°10'W.	1765	0.11	1.59	-	0.23
2	4-6-53	09°18'N.	173°18'W.	1765	0.74	2.44	-	0.06
3	4-7-53	09°13'N.	173°24'W.	1695	0.18	1.30	-	0.06
4	4-8-53	09°34'N.	173°15'W.	1725	0.12	1.85	-	0.35
5	4-9-53	09°39'N.	173°05'W.	1565	0.70	0.70	-	0.32
6	4-11-53	10°30'N.	170°35'W.	1750	0.06	1.66	-	0.06
7	4-12-53	10°50'N.	170°45'W.	1750	0.17	0.97	-	0.06
8	4-13-53	10°50'N.	170°34'W.	1725	0.17	1.16	-	0.17
9	4-14-53	10°28'N.	170°45'W.	1675	0.66	2.27	-	0.60
10	4-15-53	10°29'N.	170°46'W.	1725	0.17	1.39	-	0.58
11	4-16-53	10°08'N.	170°59'W.	1725	0.06	1.04	-	0.12
12	4-18-53	10°27'N.	170°24'W.	1765	0.28	1.87	-	0.06
13	4-19-53	10°28'N.	170°38'W.	1750	0.40	2.17	-	0.11
14	4-20-53	10°28'N.	170°56'W.	1750	0.51	3.20	-	0.11
15	4-21-53	10°30'N.	170°51'W.	1740	0.34	1.89	-	0.11
16	4-22-53	10°30'N.	171°17'W.	1735	0.58	2.71	-	0.23
17	4-23-53	10°30'N.	171°29'W.	1720	0.41	2.50	-	0.29
18	4-24-53	10°17'N.	171°47'W.	1700	0.12	3.18	-	0.06
1	6-22-53	03°13'N.	176°25'W.	1730	5.72	0.81	0.35	0.06
2	6-23-53	03°45'N.	176°13'W.	1730	8.38	0.46	0.40	-
3	6-24-53	03°20'N.	175°57'W.	1730	4.57	1.27	0.35	-
4	6-25-53	03°42'N.	175°58'W.	1730	5.78	0.87	0.40	-
5	6-26-53	03°28'N.	176°46'W.	1730	9.25	0.81	0.23	0.06
6	6-27-53	03°48'N.	175°53'W.	1730	9.02	0.75	0.58	-
7	6-28-53	03°54'N.	175°51'W.	1625	5.97	0.98	0.12	0.12
8	6-29-53	04°10'N.	176°06'W.	1675	4.06	0.84	0.12	0.24
9	6-30-53	04°05'N.	176°06'W.	1730	4.10	1.04	0.17	-
10	7-1-53	04°05'N.	176°12'W.	1730	3.64	1.04	0.06	0.12
11	7-2-53	04°10'N.	176°24'W.	1725	5.21	0.87	0.06	0.06
12	7-3-53	04°06'N.	176°17'W.	1730	5.26	0.46	0.06	-

Table 14.--Lengths of yellowfin taken during 1953. Oceanic yellowfin are tabulated by longitude and month. The majority of the insular (within 80 miles from land) yellowfin were taken near the Line Islands

Midpoint (cm.)	140°W. March	150°W. Feb.	150°W. May	155°W. Aug.	155°W. Dec.	160°W. Aug.	170°W. June	Insular Jan.-Dec.
67	-	-	-	-	-	-	-	1
72	-	-	1	-	-	-	-	2
77	-	-	-	-	-	1	-	3
82	-	-	-	-	-	-	1	3
87	-	-	-	1	-	1	2	5
92	-	-	-	-	-	-	-	10
97	-	-	2	2	-	-	2	27
102	-	-	1	3	-	-	1	29
107	-	-	-	2	3	1	1	40
112	1	-	2	5	3	-	-	19
117	-	-	1	4	3	3	-	20
122	-	1	2	4	5	3	7	21
127	-	1	7	7	4	6	11	24
132	6	8	9	10	3	4	19	49
137	14	18	19	19	11	9	31	59
142	41	31	27	36	13	15	22	87
147	35	26	10	33	13	9	14	40
152	19	9	11	14	4	8	4	36
157	3	5	7	4	1	1	1	12
162	4	2	1	2	-	1	-	5
167	1	-	-	-	-	-	-	-

Table 15. --Length frequencies of tuna taken during 1953 arranged by sex

Mid-point (cm.)	Yellowfin ♂	Yellowfin ♀	Bigeye ♂	Bigeye ♀	Albacore Mid-point (cm.)	Albacore ♂	Albacore ♀	Skipjack Mid-point (cm.)	Skipjack ♂	Skipjack ♀
67	2	-	-	-	78	1	-	47	1	-
72	1	2	-	-	79	-	1	48	-	1
77	2	2	1	-	82	1	-	52	-	. 1
82	2	2	-	-	83	-	1	53	1	-
87	2	7	-	-	85	-	1	55	-	1
92	4	6	1	1	86	-	1	56	-	1
97	20	13	1	1	87	-	6	60	1	-
102	17	17	3	-	88	-	1	61	1	-
107	24	23	3	3	89	-	3	64	-	1
112	14	16	1	1	90	1	-	67	-	1
117	13	18	2	2	91	1	5	68	-	1
122	23	20	1	3	92	2	10	70	-	3
127	31	29	8	4	93	1	8	71	-	3
132	61	48	3	2	94	10	8	72	2	4
137	76	106	5	1	95	7	7	73	1	3
142	154	119	10	5	96	5	1	74	2	1
147	150	30	7	2	97	6	1	75	1	4
152	94	12	10	4	98	6	4	76	5	-
157	30	4	12	5	99	3	1	77	1	3
162	14	1	5	4	100	11	-	78	4	3
167	-	1	10	3	101	6	-	79	-	1
172	-	-	9	1	102	14	1	80	6	1
177	-	-	3	1	103	5	-	81	1	1
182	-	-	3	-	104	1	-	82	-	2
					105	3	1	83	2	-
								84	1	-

Table 16.--Manning cruise 14, complete catch records (see table 6 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

A. Regular gear - six 15-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks: White-tipped	Sharks: Silky	Sharks: Great blue	Others
1	39	-	-	-	-	7	-	-	-	4 1/
2	40	-	1	-	-	-	-	-	-	1 2/
3	40	-	-	-	-	-	-	-	-	2 2/
4	38	-	1	-	-	-	2	-	2	-
5	40	3	-	-	1	-	1	-	1	-
6	40	7	-	-	-	-	-	1	-	1 3/
7	40	4	-	-	2	-	1	3	1	2 4/
8	39	10	-	-	1	-	-	2	-	1 3/
10	40	2	-	-	-	-	3	-	-	-
11	40	10	1	-	3	-	6	1	-	-
12	40	10	3	-	-	-	3	-	-	1 5/
17	40	-	2	1	2	1	2	2	2	-
18	40	3	-	2	-	1	-	1	2	1 3/
19	40	4	2	-	-	2	2	-	-	-
20	40	3	-	6	1	-	-	-	3	-
21	40	3	-	3	-	2	4	-	-	-
22	40	1	-	3	-	3	2	-	-	4 6/
24	40	7	-	5	-	3	1	1	1	5 7/
25	40	2	1	11	-	3	7	-	-	-
26	40	19	2	-	-	1	11	-	1	2 8/
27	40	1	2	-	4	3	-	1	1	-
28	40	6	2	-	1	1	3	-	-	-
29	40	16	3	-	-	2	5	2	-	1 10/
32	40	15	6	-	-	-	2	1	1	1 9/
33	40	42	-	-	2	2	2	-	1	-
34	40	22	1	-	1	1	2	-	1	-
35	40	18	-	-	-	1	5	2	1	1 10/
36	40	12	4	-	2	2	1	3	1	3 11/
37	40	14	1	-	1	-	3	-	2	-

1/ 2 dolphin, 2 lancent fish; 2/ lancet fish; 3/ wahoo; 4/ mako shark, unidentified shark; 5/ unidentified shark-eaten tuna; 6/ barracuda; 7/ 3 wahoo, 1 lancet fish, 1 unidentified shark-eaten tuna; 8/ 2 black-tipped sharks; 9/ sailfish; 10/ unidentified shark; 11/ 2 wahoo, 1 lancet fish

Table 16.--*Manning* cruise 14, complete catch records (see table 6 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack) (cont'd)

B. Experimental gear - six 1-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks White-tipped	Sharks Silky	Sharks Great blue	Others
1	19	-	-	-	-	-	-	-	-	3[1/]
2	20	-	1	-	-	1	-	-	-	3[2/]
3	20	1	-	-	-	-	-	-	-	-
7	20	6	1	-	1	1	-	-	-	-
8	20	3	-	-	-	-	-	1	-	-
10	20	3	-	-	-	1	1	-	-	1[3/]
11	20	7	-	-	-	-	6	2	1	-
12	20	2	-	-	2	1	-	-	-	-
17	20	2	-	-	1	-	1	-	-	1[3/]
18	20	5	-	-	-	1	-	-	-	1[4/]
19	20	1	-	5	1	-	-	-	1	-
20	20	9	-	-	-	-	-	-	1	-
21	20	3	-	3	2	4	2	-	-	-
22	20	-	-	-	-	-	6	-	-	-

1/ 2 lancet fish, 1 dolphin

2/ dolphin, 2 short-nosed spearfish

3/ wahoo

4/ short-nosed spearfish

Table 16.--Manning cruise 14, complete catch records (see table 6 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack) (cont'd)

C. Complete catch records of special stations (10 baskets per group - 60 hooks)

12-hour series 1/										
Station	Group	Time started to haul	YF	BE	Alb.	SJ	Marlin	Sharks: White-tipped	Sharks: Great blue	Others
14	I	0931	3	2	-	-	-	3	-	-
01°19'S.	II	1216	4	1	-	-	-	-	-	-
150°24'W.	III	1517	1	2	1	1	-	1	-	-
	IV	1720	4	5	-	-	1	5	-	1 2/
16	I	0913	2	-	-	-	-	-	-	-
01°25'S.	II	1209	-	1	-	-	-	3	-	-
150°45'W.	III	1512	1	-	-	-	-	1	-	-
	IV	1818	3	-	-	-	-	3	1	-

1/ All four groups set consecutively beginning at 0611 hours at station 14 and 0618 hours at station 16, then each group of 10 baskets was hauled as shown.

2/ unidentified shark

24-hour series								
Station	Group	Time started to set	Time started to haul	YF	BE	SJ	Sharks: White-tipped	Sharks: Silky
15	I	0610	0914	2	-	-	3	-
01°19'S.	II	1006	1319	1	-	-	4	-
150°36'W.	III	1405	1715	1	-	1	3	-
	IV	1806	2126	-	2	-	-	-
	V	2219	0117	-	-	-	-	-
	VI	0204	0519	-	-	-	6	1
30	I	0613	0921	-	-	-	7	-
01°48'S.	II	1002	1326	2	-	-	10	-
139°59'W.	III	1410	1729	3	-	-	1	-
	IV	1758	2126	-	-	-	1	1
	V	2208	0130	-	-	-	2	-
	VI	0208	0532	-	-	-	3	-

Table 17.--*Smith* cruise 19, complete catch records (see table 7 for station locations)

A. Regular gear - six 15-fathom droppers per basket

Station	Number of baskets	Yellow-fin	Big-eye	Marlin	Sharks			Others
					White-tipped	Silky	Great blue	
53	40	29	-	-	-	11	-	-
56	40	7	-	1	-	3	-	-
58	40	5	-	-	1	2	1	1 1/
60	40	- 2/	-	1	-	1	2	-
62	40	4	-	-	2	5	-	1 3/
63	40	18	-	1	-	7	-	3 4/
68	40	11	1	-	-	6	-	1 5/

1/ lancet fish
2/ includes 1 yellowfin caught on end hook
3/ wahoo
4/ 2 unidentified sharks, 1 thresher shark
5/ unidentified shark

B. Experimental gear - six 1-fathom droppers per basket

Station	Number of baskets	Yellow-fin	Skip-jack	Marlin	Sharks		Others
					Silky	Great blue	
53	10	14	-	-	6	-	-
56	10	7	-	1	5	-	-
58	10	6 1/	-	-	-	1	-
60	10	-	1	-	-	2	-
62	10	5	-	-	-	-	-
63	10	13 1/	-	-	5	-	1 2/
68	10	8	-	-	4	-	-

1/ includes 1 yellowfin caught on end hook
2/ unidentified shark

Table 17.--Smith cruise 19, complete catch records (see table 7 for station locations) (cont'd)

C. Complete catch records of special stations (10 baskets per group - 60 hooks)

12-hour series[1]					
Station	Group	Time started to haul	Yellowfin	Silky shark	Others
66 01°59'N. 157°31'W.	I II III IV	0817 1106 1352 1702	20 10 11 6	- 7 3 3	- 1[2] - -

[1] All four groups set as a unit beginning at 0507 hours, then each group of 10 baskets was hauled as shown

[2] wahoo

Table 18.--Manning cruise 15, complete catch records (see table 8 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

A. Regular gear - six 15-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks			Others
							White-tipped	Silky	Great blue	
1	40	-	-	-	-	-	-	-	-	2[1]
2	40	-	1	-	-	-	3	-	7	5[2]
3	40	1	9	-	-	-	-	-	2	2[3]
5	40	4	7	-	-	-	-	2	-	1[4]
6	40	1	7	-	-	-	1	1	-	1[1]
7	39	24	-	3	3	-	1	2	-	2[5]
8	40	19	-	3	1	1	-	1	-	3[6]
10	40	5	-	1	1	-	-	1	1	-
11	40	4	-	-	-	-	10	7	-	1[4]
12	40	6	-	2	1	-	2	1	-	-
13	40	-	4	-	2	-	8	1	-	1[7]
14	40	6	-	4	-	2	1	-	-	1[4]
15	40	1	2	5	-	3	1	1	1	1[5]
16	40	4	2	5	1	1	5	-	4	-
17	40	5	-	9	-	-	3	-	-	1[8]
18	40	1	4	17	2	1	16	-	2	-
19	40	15	-	5	-	-	9	-	4	1[8]
20	41	2	1	7	-	-	1	1	4	-
21	40	5	-	2	1	1	2	-	-	1[9]
22	40	18	-	-	1	1	3	-	1	1[4]
23	40	13	-	-	-	-	1	3	3	-
24	40	17	-	-	-	1	2	2	1	-
25	40	19	-	-	1	1	-	-	2	1[10]
26	40	17	-	-	-	1	1	-	4	-
27	40	4	-	-	-	1	2	2	-	1[10]
28	40	3	5	-	1	-	1	-	2	1[5]
29	40	3	4	-	-	3	1	1	1	-

[1] dolphin; [2] 1 mako shark, 1 dolphin, 2 lancet fish, 1 short-nosed spearfish; [3] 1 thresher shark, 1 lancet fish; [4] mako shark; [5] 2 lancet fish; [6] 2 mako sharks, 1 lancet fish; [7] unidentified shark; [8] short-nosed spearfish; [9] barracuda; [10] wahoo

Table 18.--*Manning* cruise 15, complete catch records (see table 8 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack) (cont'd)

B. Experimental gear - eleven 3-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks: White-tipped	Sharks: Silky	Sharks: Great blue	Others
1	10	-	-	-	-	-	-	-	-	-
2	10	-	-	-	-	1	-	-	1	2[1]
3	10	1	1	-	-	-	-	1	-	-
5	10	-	2	-	-	-	-	-	3	1[2]
6	10	-	1	-	-	1	-	1	1	2[3]
7	10	14	1	3	3	-	-	1	-	-
8	10	4	-	1	-	-	-	-	-	-
10	10	5	-	-	-	-	-	-	-	1[4]
11	10	3	-	-	-	-	2	2	-	-
12	10	5	1	1	3	-	1	-	-	-
13	10	-	-	-	-	-	2	2	-	-
14	11	-	-	3	-	1	-	-	1	1[5]
15	10	-	-	1	-	3	-	-	-	-
16	10	-	-	2	-	-	5	-	1	-
17	10	-	-	3	-	-	-	-	-	-
18	10	4	-	11	-	-	-	-	-	-
19	10	2	-	6	-	-	3	-	-	-
20	10	4	-	3	-	-	-	1	-	-
21	10	5	-	1	-	-	1	-	-	-
22	10	5	-	-	-	-	1	1	-	-
23	10	9	-	-	1	-	1	5	-	-
24	10	3	-	-	-	-	1	-	1	-
25	10	5	-	-	-	1	-	-	-	-
26	10	1	-	-	-	-	-	1	-	-
27	10	3	-	-	-	-	-	-	-	-
28	10	-	1	-	-	-	-	-	-	-
29	10	-	4	-	-	-	-	-	-	-

1/ lancet fish, short-nosed spearfish
2/ unidentified shark-eaten tuna
3/ dolphin, mako shark
4/ wahoo
5/ lancet fish

Table 18.--Manning cruise 15, complete catch records (see table 8 for station locations) (YF=yellowfin, BE=bigeye, Alb.= albacore, SJ=skipjack) (cont'd)

C. Complete catch records of special stations (10 baskets per group - 60 hooks)

24-hour series[1]										
Station	Group	Time started to set	Time started to haul	YF	BE	Alb.	SJ	Sharks: White-tipped	Sharks: Silky	Others
9	I	0633	0933	2	-	-	-	7	1	-
02°52'N.	II	1029	1329	4	-	-	-	3	-	-
149°52'W.	III	1415	1714	1	-	3	2	1	-	-
	IV	1804	2120	-	-	-	-	3	-	-
	V	2226	0145	-	-	-	-	2	-	-
	VI	0240	0550	-	-	-	-	2	-	1[2]

[1] each group of 10 baskets allowed to soak for approximately three hours

[2] 1 broadbill swordfish

Table 19.--Manning cruise 16, complete catch records (see table 9 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

A. Regular gear - six 15-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks: White-tipped	Sharks: Silky	Sharks: Great blue	Others
1	29	-	-	-	-	-	-	-	-	4 1/
2	31	-	2	-	-	-	4	1	5	3 2/
4	32	-	1	-	-	1	2	2	3	6 3/
6	30	1	4	-	1	-	-	5	5	3 4/
8	30	13	-	-	-	-	2	4	-	-
9	30	9	-	-	1	-	1	-	-	-
10	28	22	1	1	-	-	2	-	1	-
11	30	14	1	1	-	-	-	1	-	-
12	30	11	2	1	-	1	-	3	1	-
13	29	28	-	1	-	-	-	9	-	-
14	30	19	-	-	-	-	-	20	-	-
16	26	6	1	-	-	-	-	3	-	-
17	30	12	-	-	1	1	1	1	2	-
18	30	5	-	7	-	-	3	2	1	-
19	30	1	-	-	-	2	1	1	-	-
20	30	5	-	1	-	2	2	-	1	2 5/
21	30	3	-	1	-	-	-	-	1	1 6/
22	30	17	1	3	-	-	2	2	-	-
23	30	6	-	-	1	-	2	3	-	1 5/
24	30	10	-	-	-	1	1	3	-	-
25	30	3	-	1	-	-	1	1	1	-
26	30	2	-	-	-	-	1	2	-	-
27	30	8	-	-	-	-	-	3	-	-
28	30	6	-	-	1	1	-	-	-	-
29	30	1	-	-	-	-	1	1	1	1 7/
30	30	-	4	-	1	-	1	2	2	5 8/

1/ 3 lancet fish, 1 sailfish
2/ 1 wahoo, 2 lancet fish
3/ 1 wahoo, 3 dolphins, 2 sailfish
4/ 1 wahoo, 1 lancet fish, 1 dolphin
5/ barracuda
6/ broadbill swordfish
7/ lancet fish
8/ 1 mako shark, 2 lancet fish, 2 sailfish

Table 19.--*Manning* cruise 16, complete catch records (see table 9 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack) (cont'd)

B. Experimental gear - eleven 1-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks: White-tipped	Sharks: Silky	Sharks: Great blue	Others
1	19	-	-	-	-	-	-	1	-	1 1/
2	19	-	1	-	-	-	-	-	3	2 2/
4	17	1	3	-	-	2	1	-	-	2 3/
6	20	1	4	-	-	1	-	2	-	1 4/
8	20	7	4	-	-	-	2	1	1	-
9	20	2	-	-	-	1	1	2	1	1 4/
10	19	14	-	-	-	1	-	-	-	-
11	15	2	-	-	-	-	1	-	2	-
12	20	14	-	-	-	-	-	2	-	2 7/
13	20	16	-	1	-	2	-	4	-	-
14	18	21	-	-	-	-	-	10	-	1 5/
16	20	7	1	-	-	-	-	-	-	-
17	20	13	-	-	-	-	2	1	-	-
18	20	8	-	3	2	-	-	-	-	-
19	20	4	-	-	-	-	1	-	-	-
20	20	3	-	1	-	3	1	-	2	1 1/
21	20	6	-	4	2	-	-	-	1	-
22	20	5	-	1	1	-	1	-	-	-
23	20	5	-	-	-	-	-	2	-	-
24	20	13	-	-	-	1	-	1	-	-
25	20	2	-	-	-	-	-	3	-	-
26	20	8	-	-	-	-	1	2	-	-
27	20	5	1	-	1	-	-	3	-	1 6/
28	20	2	-	-	-	2	-	-	-	-
29	20	1	6	-	-	-	2	1	-	1 6/
30	20	2	1	-	-	1	1	1	1	2 3/

1/ barracuda
2/ 1 lancet fish, 1 wahoo
3/ 1 lancet fish, 1 sailfish
4/ wahoo
5/ thresher shark
6/ mako shark
7/ unidentified shark-bitten tuna, wahoo

Table 19.--Manning cruise 16, complete catch records (see table 9 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack) (cont'd)

C. Experimental gear - twenty-one 3-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks			Others
							White-tipped	Silky	Great blue	
1	10	-	-	-	-	-	-	-	-	-
2	10	-	2	-	-	1	1	-	3	1 1/
4	10	-	3	-	-	-	2	1	1	1 2/
6	10	-	3	-	-	1	-	3	2	2 3/
8	10	8	3	-	-	-	-	3	2	-
9	9	3	1	-	-	-	-	1	-	-
10	6	9	-	1	-	-	-	1	1	-
11	5	4	-	-	-	-	-	-	-	1 3/
12	5	3	-	-	-	-	-	2	-	-
13	5	20	-	2	-	-	-	6	-	-
14	4	11	-	-	-	-	-	10	-	1 4/
16	10	1	-	1	1	-	-	2	1	-
24	10	11	-	-	-	-	1	-	-	-
25	10	3	-	-	1	-	-	-	1	-
26	10	12	-	-	-	1	2	-	-	-
27	10	13	1	-	-	1	-	4	-	-
28	10	3	-	-	-	1	-	1	1	-
29	10	1	-	-	1	-	-	-	-	3 5/

1/ wahoo

2/ lancet fish

3/ barracuda

4/ thresher shark

5/ dolphin

Table 20.--Manning cruise 17, complete catch records (see table 10 for station locations) (YF=yellowfin, BE=bigeye, Alb.= albacore, SJ=skipjack)

A. Regular gear - six 15-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks		Others
							Silky	Great blue	
2	30	13	1	-	-	-	2	1	-
3	30	10	-	-	-	1	3	-	-
4	21	13	-	-	-	-	11	-	-
5	20	15	2	2	1	-	2	-	1[1/]
6	19	8	-	1	-	-	1	-	-
7	19	13	-	1	-	1	4	-	-

1/ wahoo

B. Experimental gear - eleven 3-fathom droppers per basket

Station	Number of baskets	YF	BE	SJ	Marlin	Sharks			Others
						White-tipped	Silky	Great blue	
2	30	10	-	3	1	2	1	1	1[1/]
3	30	8	-	-	1	-	7	-	-
4	22	14	-	-	1	-	8	-	2[2/]
5	20	15	2	-	2	-	2	-	-
6	21	15	1	-	1	-	3	-	1[3/]
7	21	15	-	-	-	-	4	-	-

1/ lancet fish

2/ 1 thresher shark, 1 unidentified shark

3/ unidentified shark-eaten tuna

Table 21.--Manning cruise 18, complete catch records (see table 11 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack)

A. Regular gear - six 15-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks: White-tipped	Sharks: Silky	Sharks: Great blue	Others
2	30	6	-	1	-	2	3	-	-	1[1/]
5	30	4	1	-	-	-	-	2	-	-
8	30	15	-	-	-	-	4	2	1	1[2/]
10	30	-	-	-	-	-	6	2	-	-
12	30	4	-	-	1	-	4	8	-	-
14	30	4	-	-	-	-	6	5	1	2[3/]
16	30	5	-	-	1	-	2	7	-	-
18	30	24	-	-	-	-	1	5	-	-
19	30	5	-	-	-	-	-	1	2	-
21	30	2	-	-	-	1	4	-	-	-
23	30	4	-	-	-	-	1	2	1	1[2/]
25	30	1	-	-	-	-	3	2	1	1[2/]
27	30	-	2	-	1	-	2	-	4	3[4/]
29	30	-	-	-	-	-	-	2	-	5[5/]

1/ wahoo

2/ lancet fish

3/ sailfish

4/ 2 lancet fish, 1 wahoo

5/ 2 dolphins, 3 thresher sharks

Table 21.--Manning cruise 18, complete catch records (see table 11 for station locations) (YF=yellowfin, BE=bigeye, Alb.=albacore, SJ=skipjack) (cont'd)

B. Experimental gear - eleven 3-fathom droppers per basket

Station	Number of baskets	YF	BE	Alb.	SJ	Marlin	Sharks			Others
							White-tipped	Silky	Great blue	
2	30	4	-	1	2	-	-	2	-	-
5	30	4	-	-	-	-	-	2	-	1 1/
8	30	11	1	-	-	-	2	-	-	-
10	30	-	-	-	-	2	6	3	-	1 2/
12	30	6	-	-	-	-	5	8	-	-
14	30	12	-	-	-	-	9	11	1	-
16	30	17	1	-	-	-	8	7	-	-
18	30	22	-	-	-	1	-	5	1	1 1/
19	30	6	-	-	-	-	-	5	-	-
21	30	11	1	-	-	-	2	4	-	1 3/
23	30	3	-	-	-	-	2	5	-	1 4/
25	30	1	1	-	-	-	1	-	1	1 5/
27	30	-	1	-	-	-	5	1	1	4 6/
29	30	-	-	-	1	-	-	1	1	4 7/

1/ lancet fish

2/ bonito shark

3/ dolphin

4/ sailfish

5/ wahoo

6/ 3 lancet fish, 1 wahoo

7/ 1 dolphin, 2 lancet fish, 1 thresher shark

Table 22.--*Manning* cruise 14, time taken setting and hauling the longline

Station	Set			Haul					Fish-handling break[3]
	Number of baskets	Time started to set	Time taken for setting	Time started to haul	Regular gear[1]		Experimental gear[2]		
					Number of baskets	Time taken for hauling	Number of baskets	Time taken for hauling	
			min.			min.		min.	min.
1	60	0617	73	1215	40	242	20	119	30
2	60	0630	68	1200	40	195	20	81	31
3	60	0629	71	1205	40	169	20	104	33
4	40	0635	50	1222	40	169	-	-	34
5	40	0625	52	1222	40	135	-	-	34
6	40	0627	43	1222	40	172	-	-	39
7	60	0620	63	1232	40	158	20	98	87
8	59	0629	67	1106	39	170	20	113	35
10	60	0612	66	1201	40	171	20	90	56
11	60	0615	66	1202	40	160	20	77	68
12	60	0630	67	1213	40	161	20	90	84
17	60	0610	74	1210	40	145	20	77	70
18	60	0603	66	1152	40	142	20	80	74
19	60	0612	65	1210	40	158	20	71	62
20	60	0715	67	1200	40	146	20	76	68
21	60	0610	68	1209	40	130	20	86	24
22	60	0605	68	1208	40	143	20	65	67
24	40	0603	45	1203	40	198	-	-	77

1/ Six 15-fathom droppers per basket
2/ Six 1-fathom droppers per basket
3/ Break came midway during the hauling period

Table 22.--Manning cruise 14, time taken setting and hauling the longline (cont'd)

Station	Set			Haul					Fish-handling break[3]
					Regular gear[1]		Experimental gear[2]		
	Number of baskets	Time started to set	Time taken for setting	Time started to haul	Number of baskets	Time taken for hauling	Number of baskets	Time taken for hauling	
			min.			min.		min.	min.
25	40	0551	48	1201	40	151	-	-	65
26	40	0556	47	1201	40	150	-	-	68
27	40	0600	45	1214	40	157	-	-	67
28	40	0555	48	1201	40	135	-	-	68
29	40	0554	46	1214	40	159	-	-	60
32	40	0559	44	1202	40	147	-	-	83
33	40	0601	43	1206	40	189	-	-	73
34	40	0604	45	1202	40	173	-	-	60
35	40	0559	37	1201	40	136	-	-	66
36	40	0602	41	1216	40	154	-	-	60
37	40	0600	40	1205	40	162	-	-	54
Average time per basket			1.1 min.			4.0 min.		4.4 min.	

1/ Six 15-fathom droppers per basket
2/ Six 1-fathom droppers per basket
3/ Break came midway during the hauling period

Table 23.--Smith cruise 19, time taken setting and hauling the longline

Station	Set 1/		Haul			
	Time started to set	Time taken for setting	Time started to haul	Time taken for hauling regular gear 2/	Time taken for hauling experimental gear 3/	Fish-handling break 4/
		min.		min.	min.	min.
53	0604	63	1230	163	69	35
56	0725	60	1309	145	44	38
58	0600	59	1246	148	51	41
60	0605	61	1250	281	117	42
62	0559	59	1247	161	39	47
63	0612	113	1251	164	48	39
68	0609	59	1233	153	38	43
Average time per basket		1.4 min.		4.3 min.	5.8 min.	

1/ 40 baskets of regular gear and 10 baskets of experimental gear set at each station

2/ Six 15-fathom droppers per basket

3/ Six 1-fathom droppers per basket

4/ Break came midway during the hauling period

Table 24. --*Manning* cruise 15, time taken setting and hauling the longline

Station	Time started to set	Time started to haul	Regular gear[1/]		Experimental gear[2/]		Fish-handling break[3/]
			Time taken for setting	Time taken for hauling	Time taken for setting	Time taken for hauling	
			min.	min.	min.	min.	min.
1	0915	1232	49	194	21	39	27
2	0600	1239	40	-	20	50	-
3	0603	1244	40	176	19	91	35
5	0608	1239	38	167	17	46	27
6	0608	1224	41	183	17	56	27
7	0604	1238	38	201	17	39	30
8	0603	1211	39	169	19	50	30
10	0602	1217	41	151	17	34	-
11	0602	1231	40	184	16	39	28
12	0600	1227	40	166	16	52	33
13	0605	1226	38	169	15	33	31
14	0603	1229	37	160	16	41	31
15	0601	1224	37	160	15	29	27
16	0605	1221	40	153	15	33	33
17	0634	1254	50	111	20	29	30
18	0624	1234	36	187	15	36	43
19	0628	1229	35	179	15	33	38
20	0629	1222	43	146	15	34	28

1/ Six 15-fathom droppers per basket. Set 40 baskets of gear at each station; exceptions - station 7 with 39 baskets and station 20 with 41 baskets

2/ Eleven 3-fathom droppers per basket. Set 10 baskets of gear at each station; exception - station 14 with 11 baskets

3/ Break came midway during the hauling period

Table 24.--*Manning* cruise 15, time taken setting and hauling the longline (cont'd)

Station	Time started to set	Time started to haul	Regular gear[1/]		Experimental gear[2/]		Fish-handling break[3/]
			Time taken for setting	Time taken for hauling	Time taken for setting	Time taken for hauling	
			min.	min.	min.	min.	min.
21	0622	1226	42	141	14	35	51
22	0632	1239	39	166	14	50	33
23	0623	1239	39	133	14	54	39
24	0620	1240	41	143	13	41	33
25	0626	1225	41	160	15	41	32
26	0621	1232	42	142	13	50	46
27	0625	1221	39	148	12	34	34
28	0623	1232	42	168	14	39	38
29	0623	1227	39	171	12	50	35
Average time per basket			1.0 min.	4.1 min.	1.6 min.	4.3 min.	

1/ Six 15-fathom droppers per basket. Set 40 baskets of gear at each station; exceptions - station 7 with 39 baskets and station 20 with 41 baskets

2/ Eleven 3-fathom droppers per basket. Set 10 baskets of gear at each station; exception - station 14 with 11 baskets

3/ Break came midway during the hauling period

Table 25.--*Manning* cruise 16, time taken setting and hauling the longline

Station	Set			Haul							
					Regular gear[1]		11-hook gear[2]		21-hook gear[3]		
	Number of baskets	Time started to set	Time taken for setting	Time started to haul	Number of baskets	Time taken for hauling	Number of baskets	Time taken for hauling	Number of baskets	Time taken for hauling	Fish-handling break
			min.			min.		min.		min.	min.
1	58	0626	73	1244	29	112	19	69	10	47	32
2	60	0622	74	1230	31	158	19	99	10	58	37
4	59	0639	67	1230	32	132	17	91	10	51	25
6	60	0620	66	1227	30	141	20	84	10	52	33
8	60	0621	78	1232	30	140	20	84	10	84	36
9	60	0617	71	1234	30	120	20	66	10	93	36
10[4]	60	0620	70	1232	28	148	19	147	6	49	33
11	50	0623	56	1240	30	128	15	51	5	30	30
12	55	0629	59	1237	30	145	20	92	5	27	30
13[5]	55	0618	57	1240	29	130	20	128	5	33	32
14	53	0627	56	1308	30	119	18	104	5	108	28
16	56	0625	62	1234	26	110	20	86	10	59	36
17	50	0635	62	1230	30	138	20	86	-	-	35
18	50	0625	70	1240	30	122	20	77	-	-	36
19	50	0625	66	1231	30	130	20	73	-	-	48
20	50	0629	59	1234	30	126	20	93	-	-	37
21	50	0636	61	1228	30	132	20	73	-	-	42

1/ Six 15-fathom droppers per basket
2/ Eleven 3-fathom droppers per basket
3/ Twenty-one 3-fathom droppers per basket
4/ Lost two regular gear baskets, one 11-hook gear basket, three one-half 21-hook gear baskets
5/ Lost one 11-hook gear basket

Table 25.--*Manning* cruise 16, time taken setting and hauling the longline (cont'd)

Station	Set			Haul							Fish-handling break
					Regular gear 1/		11-hook gear 2/		21-hook gear 3/		
	Number of baskets	Time started to set	Time taken for setting	Time started to haul	Number of baskets	Time taken for hauling	Number of baskets	Time taken for hauling	Number of baskets	Time taken for hauling	
			min.			min.		min.		min.	min.
22	50	0635	61	1240	30	114	20	86	-	-	31
23	50	0632	63	1242	30	150	20	89	-	-	64
24	60	0633	82	1221	30	127	20	84	10	69	49
25	60	0633	84	1230	30	122	20	59	10	50	46
26	60	0636	84	1248	30	123	20	70	10	55	36
27	60	0637	79	1250	30	141	20	73	10	64	28
28	60	0637	83	1249	30	100	20	69	10	51	41
29	60	0637	84	1249	30	109	20	68	10	46	42
30	50	0631	64	1250	30	133	20	87	-	-	41
Average time per basket			1.2			4.3		4.3		6.6	

1/ Six 15-fathom droppers per basket
2/ Eleven 3-fathom droppers per basket
3/ Twenty-one 3-fathom droppers per basket

Table 26.--Manning cruise 17, time taken setting and hauling the longline

Station	Set			Haul					Fish-handling break
	Number of baskets	Time started to set	Time taken for setting	Time started to haul	Regular gear[1]		11-hook gear[2]		
					Number of baskets	Time taken for hauling	Number of baskets	Time taken for hauling	
			min.			min.		min.	min.
2	60	0648	74	1224	30	111	30	179	34
3	60	0619	67	1221	30	126	30	141	29
4[3]	60	0628	69	1224	21	118	22	183	30
5	40	0629	49	1236	20	83	20	113	36
6	40	0626	47	1230	19	78	21	117	31
7	40	0625	49	1223	20	81	20	100	34
Average time per basket			1.2 min.			4.3 min.		5.8 min.	

1/ Six 15-fathom droppers per basket
2/ Eleven 3-fathom droppers per basket
3/ Lost 17 baskets of gear

Table 27.--*Manning* cruise 18, time taken setting and hauling the longline

Station	Set			Haul			Fish-handling break
	Number of baskets[1]	Time started to set	Time taken for setting	Time started to haul	Time taken for hauling regular gear[2]	Time taken for hauling 11-hook gear[3]	
			min.		min.	min.	min.
2	60	0700	72	1209	111	105	34
5	60	0621	67	1211	106	93	34
8	60	0625	65	1222	114	97	35
10	60	0615	70	1216	112	103	30
12	60	0628	69	1222	114	100	33
14	60	0625	69	1218	133	134	35
16	60	0620	69	1221	126	144	29
18	60	0620	70	1210	107	99	35
19	60	0626	69	1206	105	103	29
21	60	0628	69	1219	122	116	29
23	60	0617	70	1217	104	100	36
25	60	0623	71	1220	116	104	32
27	60	0620	67	1141	109	102	24
29[4]	60	0629	66	1203	126	112	22
Average time per basket			1.1 min.		3.8 min.	3.6 min.	

1/ 30 baskets of each type of gear set at each station
2/ Six 15-fathom droppers per basket
3/ Eleven 3-fathom droppers per basket
4/ Last 15 baskets hauled in at slow speed due to mechanical failure

Table 28.--Average wind direction and Beaufort force at the fishing stations[1/]

A. Oceanic stations (more than 80 miles from land)

Latitude	JRM 14 150°W. Jan.-Feb.	JRM 14 140°W. March	JRM 15 150°W. May	JRM 15 170°W. May-June	JRM 16 155°W. July	JRM 16 160°W. August	JRM 18 155°W. Dec.
16°N.	W-1	-	-	-	-	-	-
15°N.	-	-	-	-	-	-	-
14°N.	-	-	-	-	-	-	-
13°N.	-	-	-	-	-	-	-
12°N.	E-5	-	-	-	-	-	-
11°N.	-	-	-	-	-	-	-
10°N.	-	-	NE-5	-	SE-3	-	-
9°N.	-	-	NE-4	-	-	E-3	-
8°N.	-	-	-	NE-3	E-2	S-2	SE-3
7°N.	NE-5	-	NE-4	-	E-3	-	SE-3
6°N.	-	-	?-2	E-4	E-3	SE-4	SE-3
5°N.	NE-4	-	-	E-4	SE-3	-	-
4°N.	NE-4	NE-4	E-3	E-5	-	-	SE-2
3°N.	E-3	NE-3	NE-3	E-3	SE-5	-	SE-3
2°N.	E-2	N-4	NE-4	E-3	E-5	E-4	E-3
1°N.	E-2	E-3	NE-3	E-2	SE-5	E-3	E-3
0°	E-3	NE-4	-	-	E-4	-	E-4
1°N.	E-2; NE-5	NE-4	NE-2	E-2	E-5	-	E-4
2°N.	NE-4	NE-3	NE-1	-	-	-	-
3°N.	E-4	E-4	-	-	E-5	NE-3	-
4°N.	E-3	-	NE-1	-	-	-	-
5°N.	-	NE-2	N-2	-	-	-	-
6°N.	E-3	E-3	NE-2	N-2	-	-	-
7°N.	E-2	-	-	N-1	-	-	-

[1/] Averages obtained by taking three station observations (morning, noon and after hauling) and determining; (1) the general direction of the wind using eight compass points, (2) averaging the Beaufort code values.

Table 28.--Average wind direction and Beaufort force at the fishing stations[1/] (cont'd)

B. Insular stations (less than 80 miles from land)

Vessel and cruise	Station	Wind direction	Beaufort force
Smith 19	53	NE	5
	56	S	4
	58	SE	4
	60	SE	4
	62	E	4
	63	E	3
	68	E	4
Manning 14	22	SE	3
	24	NE	4
Manning 15	19	NE	3
	20	NE	2
	21	NE	2
Manning 16	12	E	4
	13	E	4
	14	E	4
	20	E	3
	22	NE	3
	23	NE	4
	26	E	4
	27	SE	3
Manning 17	2	SE	3
	3	E	2
	4	SE	3
	5	SE	4
	6	SE	2
	7	E	2
Manning 18	2	E	5
	5	E	4
	16	E	4
	18	E	4
	19	E	4

[1/] Averages obtained by taking three station observations (morning, noon and after hauling) and determining; (1) the general direction of the wind using eight compass points, (2) averaging the Beaufort code values.

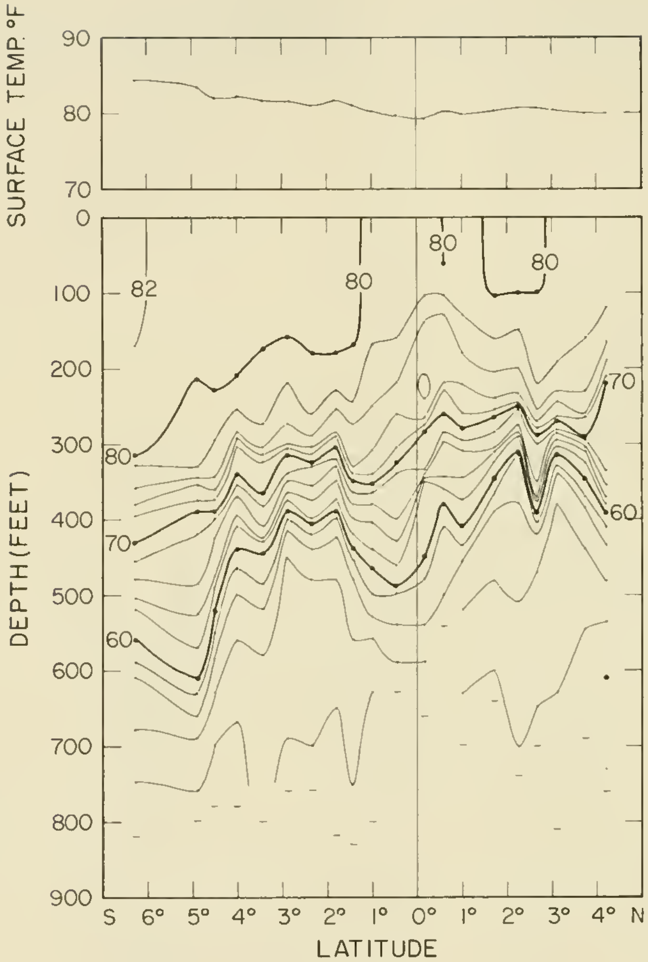

Figure 13.--Surface temperatures and vertical temperature section along 140°W. longitude, March 1953 (Manning cruise 14). Upper panel--surface temperatures as read at each bathythermograph lowering. Lower panel--temperature section based on bathythermograph lowerings; isotherms at 2°F. intervals, depth of lowering shown by small horizontal dashes.

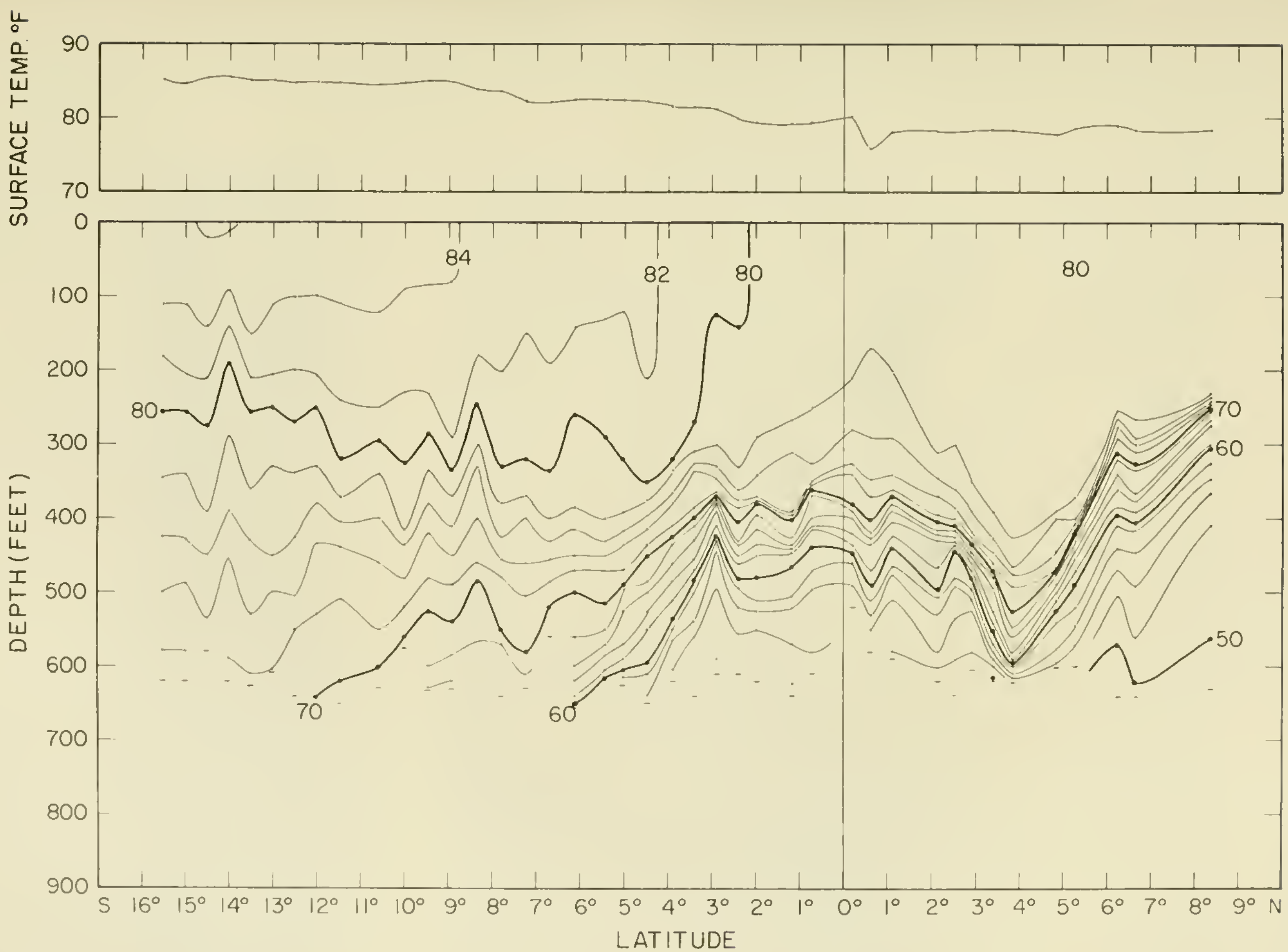

Figure 14.--Surface temperatures and vertical temperature section along 150°W. longitude, February 1953 (Manning cruise 14). Upper panel--surface temperatures as read at each bathythermograph lowering. Lower panel--temperature section based on bathythermograph lowerings; isotherms at 2°F. intervals, depth of lowering shown by small horizontal dashes.

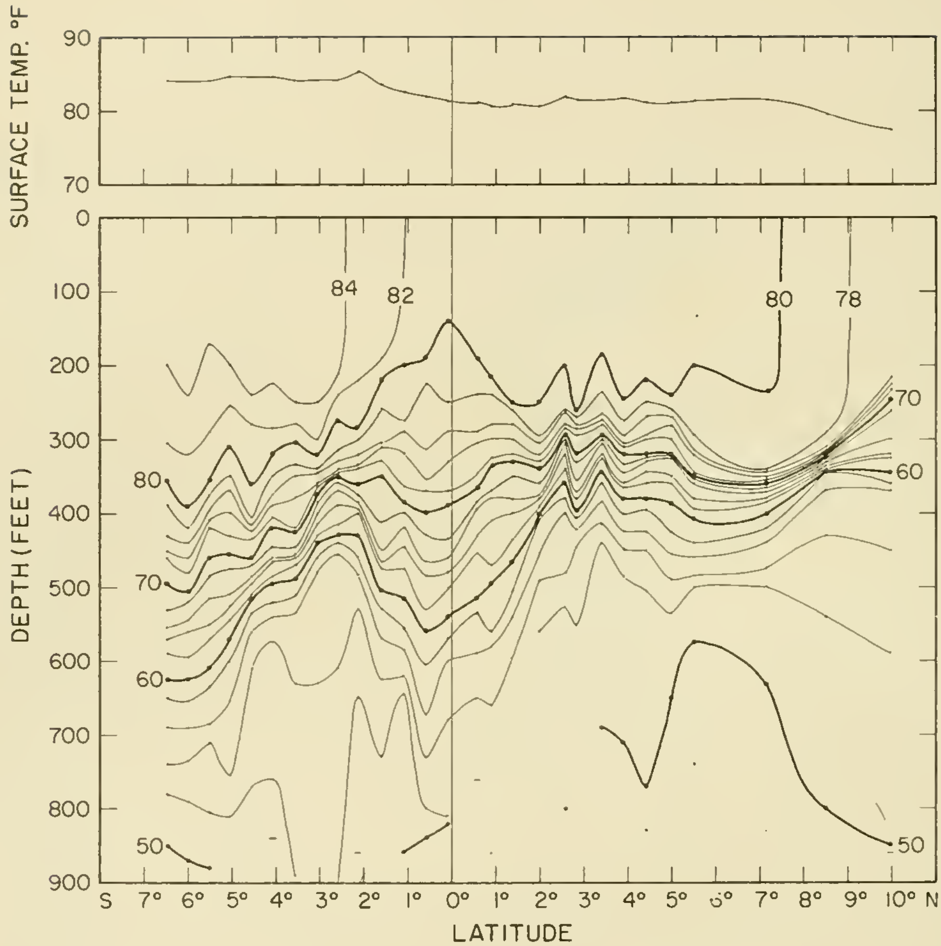

Figure 15.--Surface temperatures and vertical temperature section along 150°W. longitude, May 1953 (Manning cruise 15). Upper panel--surface temperatures as read at each bathythermograph lowering. Lower panel--temperature section based on bathythermograph lowerings; isotherms at 2°F. intervals, depth of lowering shown by small horizontal dashes.

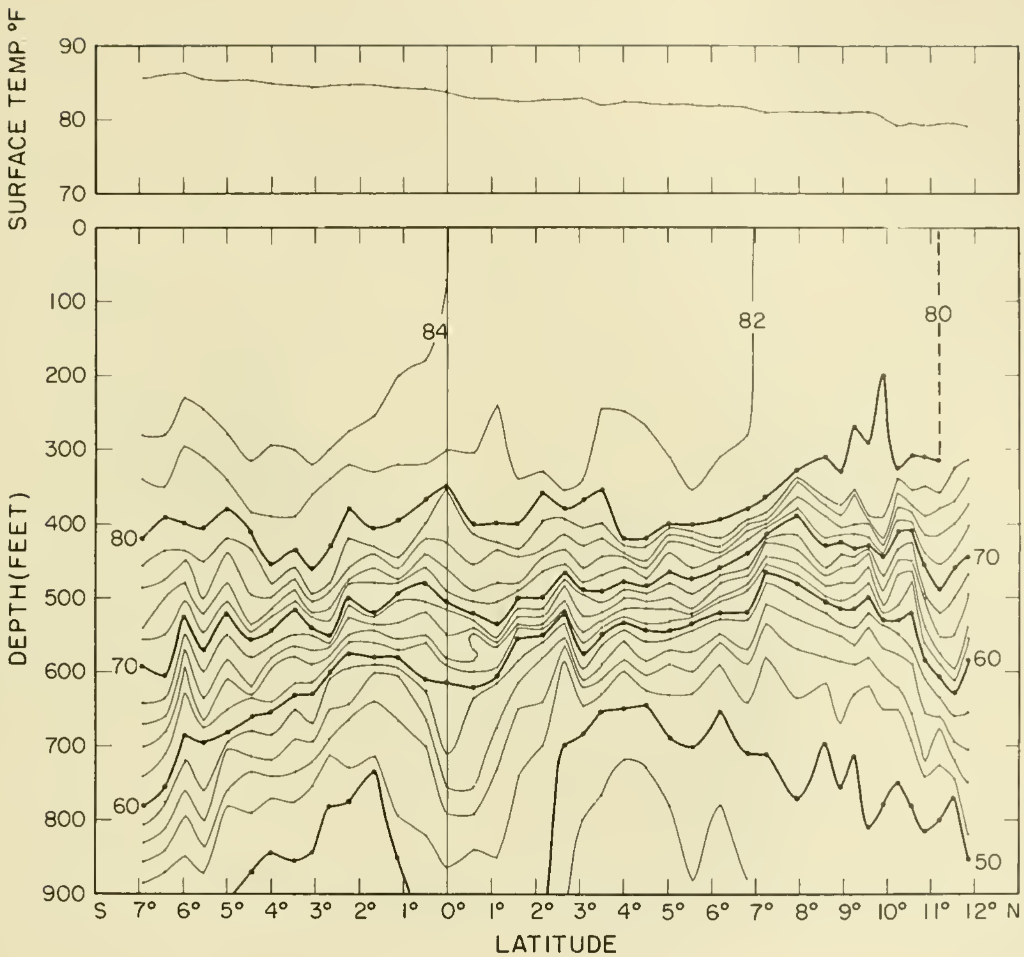

Figure 16.--Surface temperatures and vertical temperature section along 170°W. longitude, June 1953 (*Manning* cruise 15). Upper panel--surface temperatures as read at each bathythermograph lowering. Lower panel--temperature section based on bathythermograph lowerings; isotherms at 2°F. intervals, depth of lowering shown by small horizontal dashes.

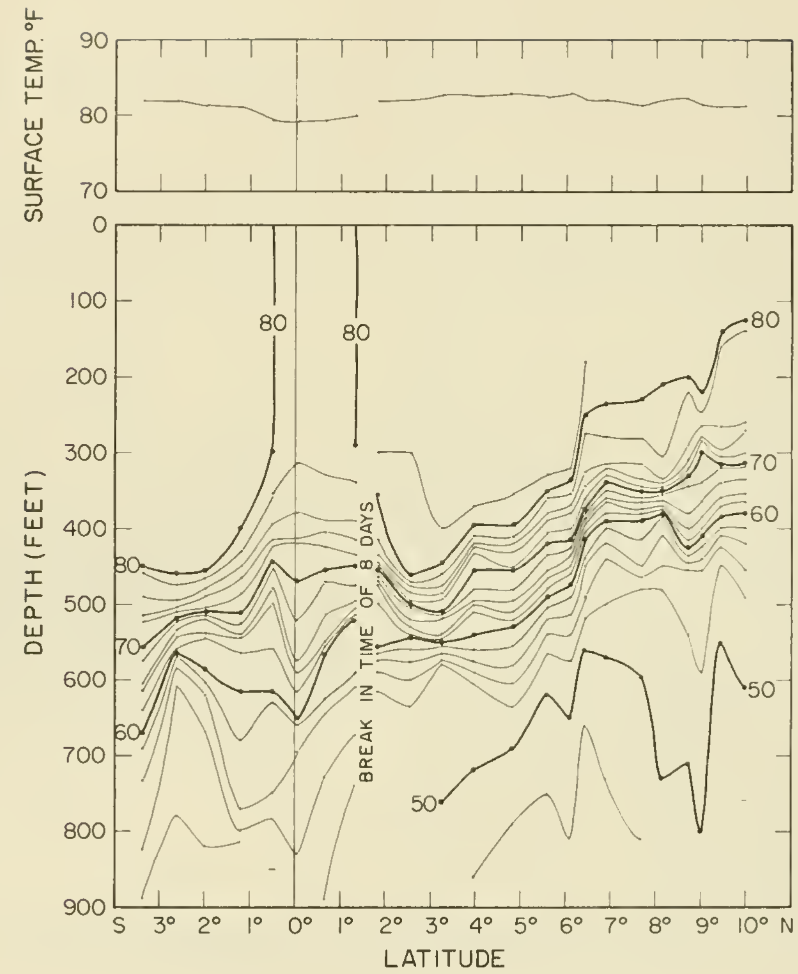

Figure 17.--Surface temperatures and vertical temperature section along 155°W. longitude, August 1953 (Manning cruise 16). Upper panel--surface temperatures as read at each bathythermograph lowering. Lower panel--temperature section based on bathythermograph lowerings: isotherms at 2°F. intervals, depth of lowering shown by small horizontal dashes.

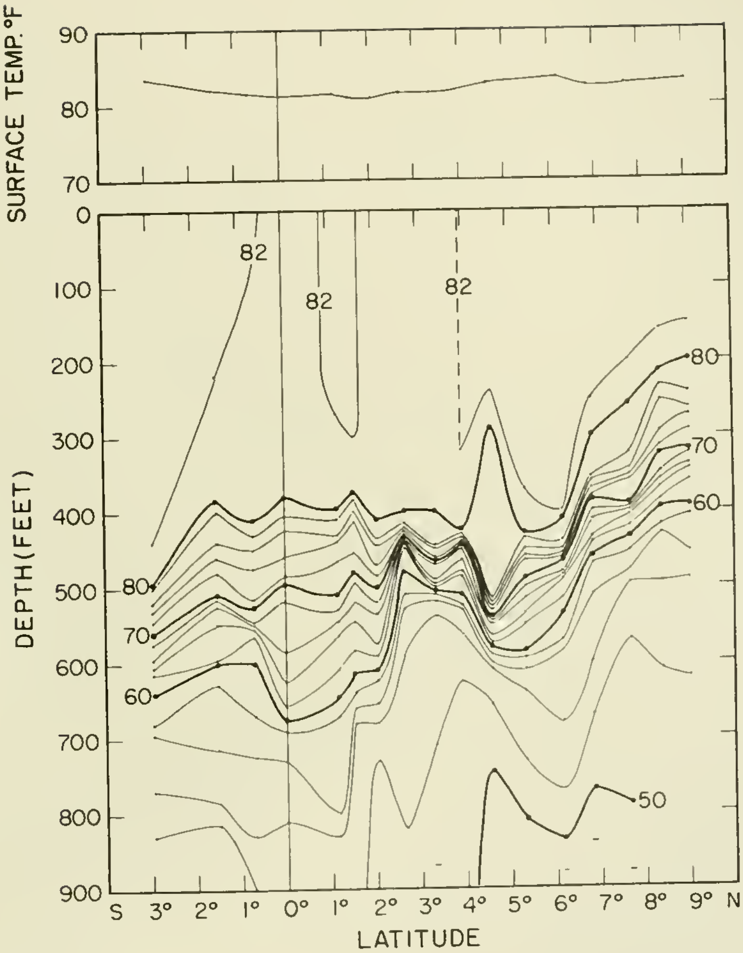

Figure 18.--Surface temperatures and vertical temperature section along 160° W. longitude, August 1953 (*Manning* cruise 16). Upper panel--surface temperatures as read at each bathythermograph lowering. Lower panel--temperature section based on bathythermograph lowerings: isotherms at 2° F. intervals, depth of lowering shown by small horizontal dashes.

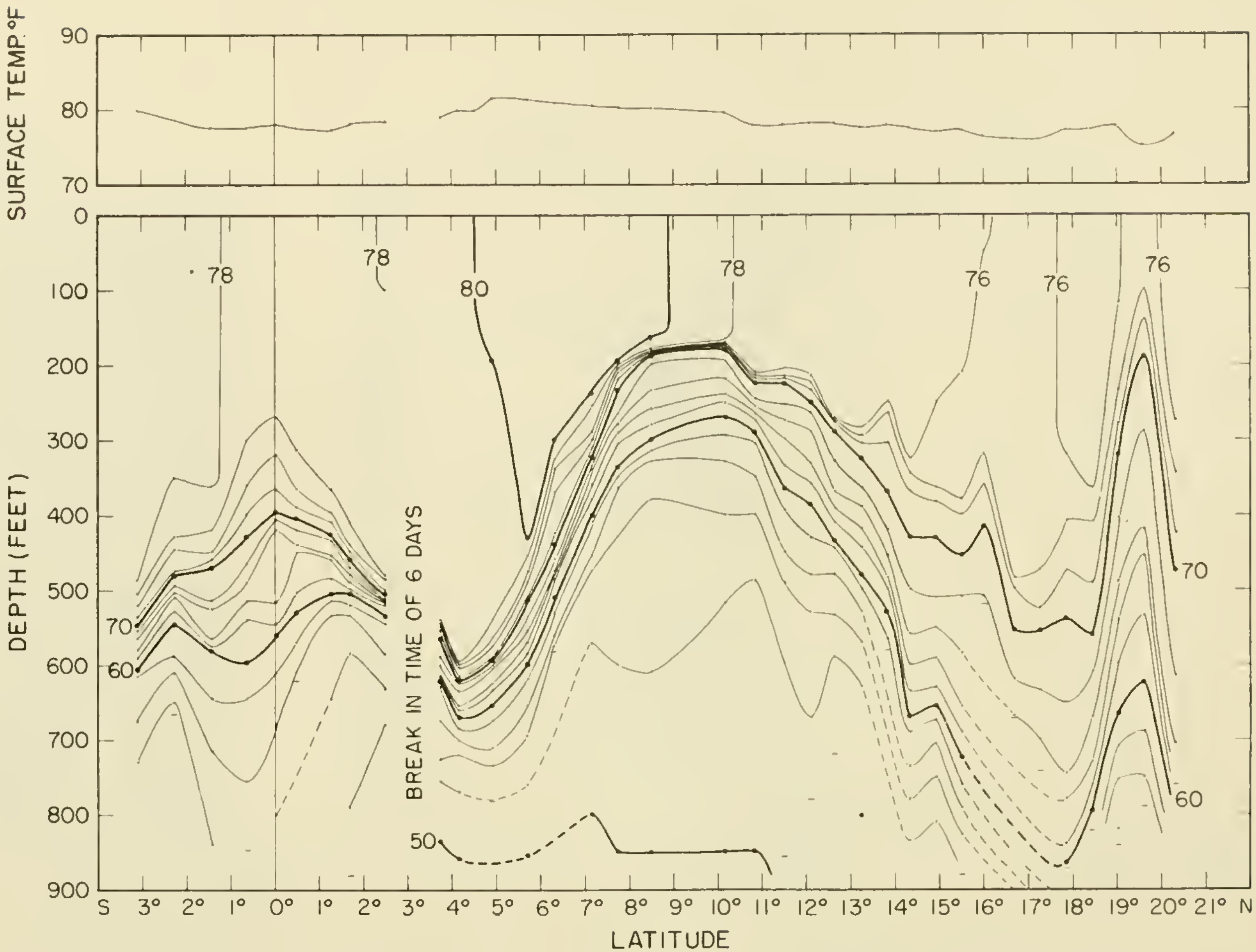

Figure 19.--Surface temperatures and vertical temperature section along 155°W. longitude, December 1953 (Manning cruise 18). Upper panel--surface temperatures as read at each bathythermograph lowering. Lower panel--temperature section based on bathythermograph lowerings; isotherms at 2°F. intervals, depth of lowering shown by small horizontal dashes.